RELATÓRIO FINAL		NÚMERO DO DOCUMENTO **CT-RE-001-2024**
NOME DO PROJETO – SUBPROJETO - ATIVIDADE **MapSãoFrancisco – Lower Stretch Francisco River** **Mapping populations in flood zones risk** **Multi purpose dynamic research trimaran – prototype**		DATA DA REALIZAÇÃO **15th January 2024**
CONVÊNIO – PATROCÍNIO – APOIO INSTITUCIONAL **Cooperação HOT – Humanitarian OpenStreetMap Team; UFAL – Universidade Federal de Alagoas; InfoSãoFrancisco**		NO. DO CONTRATO **Sem contrato**
REALIZADOR (ES) **Sociedade Socioambiental do Baixo São Francisco – Canoa de Tolda**		
RESPONSÁVEL **Carlos Eduardo Ribeiro Junior**		CARGO – FUNÇÃO **Coordinator/Developer**
ETAPA (S): **MPDT 001 construction (final) and sea trials evaluation**	SITUAÇÃO: **Finished** **Last rev. 17/07/2023**	USO: **MapSãoFrancisco/partners**
NOTA:		VERSÃO **English**

1. Background

This report is an update to the previous report, CT-RE-004-2023, with the evolution of the multi-task trimaran project for monitoring sheltered waters.

Since the application of tests with the first and rudimentary experience, which was the model made in foam (during training activities with HOT - Humanitarian OpenStreetMap Team in June/July 2022), the project evolved towards carrying out digital modeling of the concept (see CT-RE-002-2023), construction of two prototypes and is currently in the installation/system testing and sea testing phase for evolution/final validation of the project.

The two prototypes will allow the general validation of the hull design and the installation, development and development of multifunctional equipment/sensors that will enable eventual and future project/equipment updates and the scope of the vessel's activities.

2. Construção dos protótipos

We currently have two prototypes built and undergoing sea trials. One of the prototypes will have additional development for a motorized version for remote control (an aquatic drone) and/or possible autonomous operation. This internship will be carried out by Paulo Victor Araújo's team, from IFRN – Instituto Federal do Rio Grande do Norte/Mossoró, partner of MapSãoFrancisco[1], who already have extensive experience in developing robotic systems for geodata collection.

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[1] Desenvolvimento do sistema MARIA de modelagem e simulação de eventos extremos/enchentes.

As previously presented, wood/epoxy construction was selected due to our previous long-term experience (and tools) for this type of technique in various oceangoing sailings and powered multihulls around the world. However, such a technique, for good results to be obtained, depends on skills, tools, materials.

The project also has a partner in Portugal, Gladson Brabec, who is testing a reduced size version for 3D printing. We had some problems exporting the files (DXF for the general surfaces of the trimarans), but it is a question of knowing the correct way to convert these files.

We believe that, to date, the cheapest and fastest way to build these basic tracking trimaran hulls will use 3D printing and CND shaping machines (using a foam or softwood block of the material to be molded).

The aforementioned team of prof. Paulo Victor will also dedicate himself to developing a version of the trimaran for 3D printing in order to enable the equipment to be distributed, at low cost, anywhere in the world.

It is worth noting that the prototype construction process prioritized the use of materials easily found in precarious stores, a situation common to numerous locations around the world, where the trimaran's potential user public is found.

3. Trimaran finishing/painting

Two initial layers of high-resistance water-based epoxy paint were applied to the finished cell of the prototypes, coated with Scuna epoxy resin, which provides additional protection to the hull material, especially against abrasion.

For the purpose of pre-finishing the hulls, a basic painting was carried out (conventional paint, low-cost single-component synthetic enamel) which allows interventions in the cells without loss of investment in the material(s).

Due to the high temperatures in the trimaran's initial operating regions, the color white was chosen for the deck and part of the side. This way, the compartment for any equipment (batteries, controls, sensors, etc.) will not be subjected to higher temperatures.

The sides and bottom of the hulls were painted in red (we would have appreciated a high-visibility orange fluorescent dayglow pattern, but it was impossible to find on the local market).

As this is pre-production equipment, with priority for qualification and validation tests, no hours were allocated for fine finishing on the general surfaces of the trimarans. Such action may be carried out later at any time.

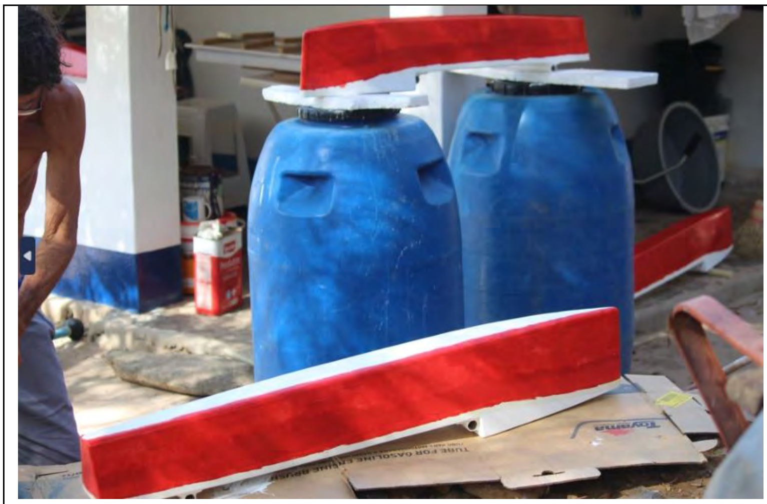


Figure 1 - Painting of trimaran prototypes.

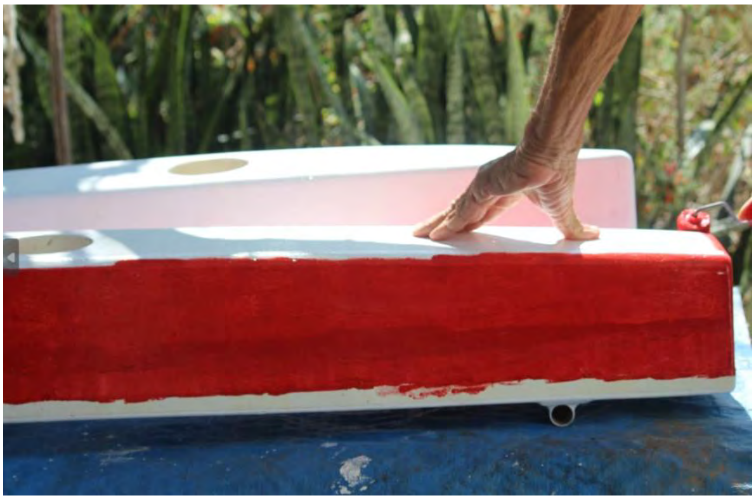


Figure 2 - Idem.

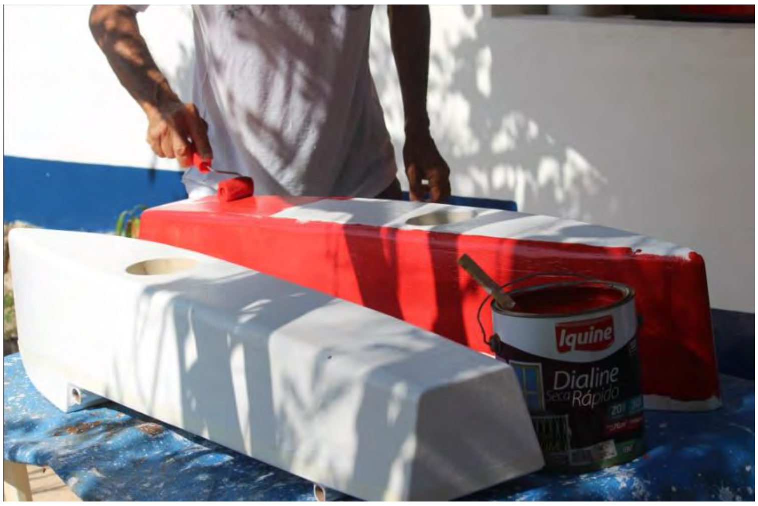


Figure 3 - Idem. Note: One of the central hulls with the white epoxy base.

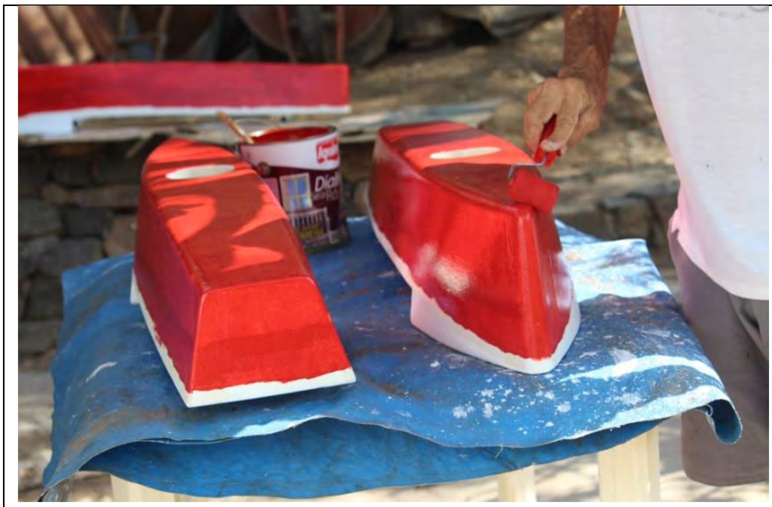


Figure 4 - Idem.

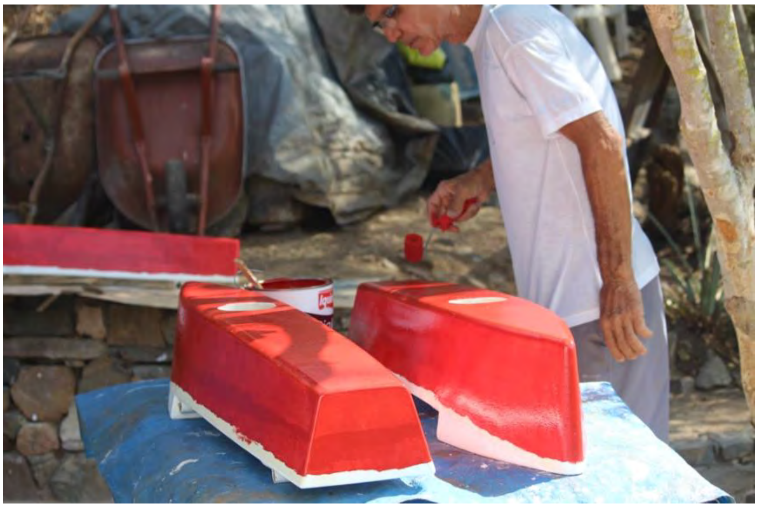


Figure 5 - Idem.

4. Sonar instalation device

With the excellent choice of the Deeper Pro probe and the positive experience of the foam pre-prototype (see report CT-RE-003-2022), the trimaran prototypes had their design carried out “around” the sonar, which has a spherical.

At the same time, the project was also supported by the possibility of expanding the scope of use of the trimaran, with possible motorized versions (remotely controlled and/or autonomous) capable of receiving other equipment such as an ADCP - Acoustic Doppler Current Profiler). The idea therefore evolved into a standard fitting amidships of the central hull with a diameter of 100 mm (standard diameter of a basic ADCP). This fitting will accommodate different plugs in which, in turn, probes and different sensors will be installed for a varied range of data collection.

For prototypes in use, we have plugs for the Deeper Pro probe and plugs ready to receive any other type of probe or sensors.

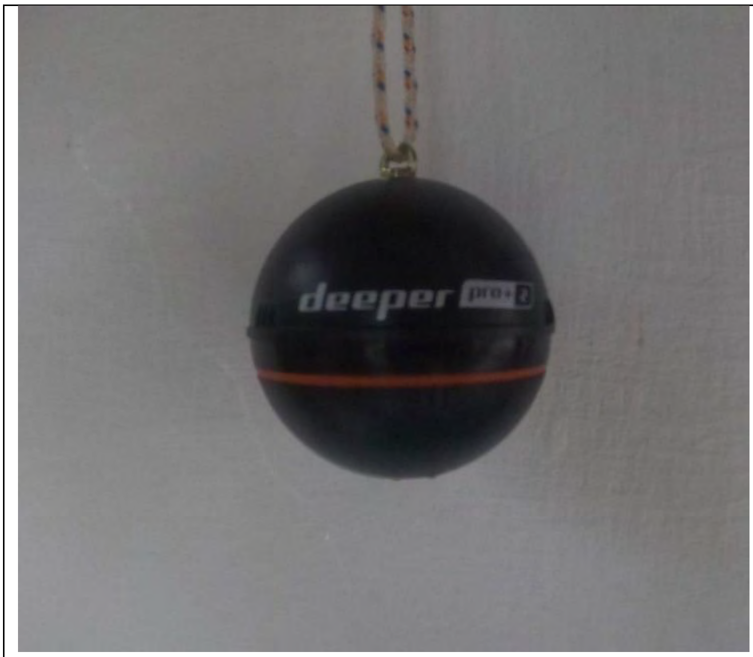


Figure 6 - The Deeper Pro sonar.

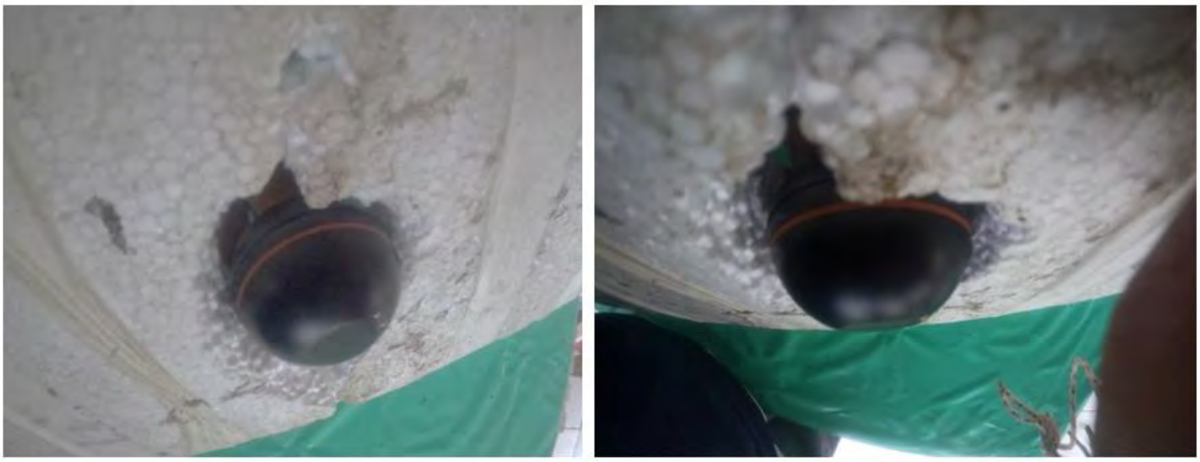


Figure 7 - The Deeper Pro probe in the foam pre-prototype.

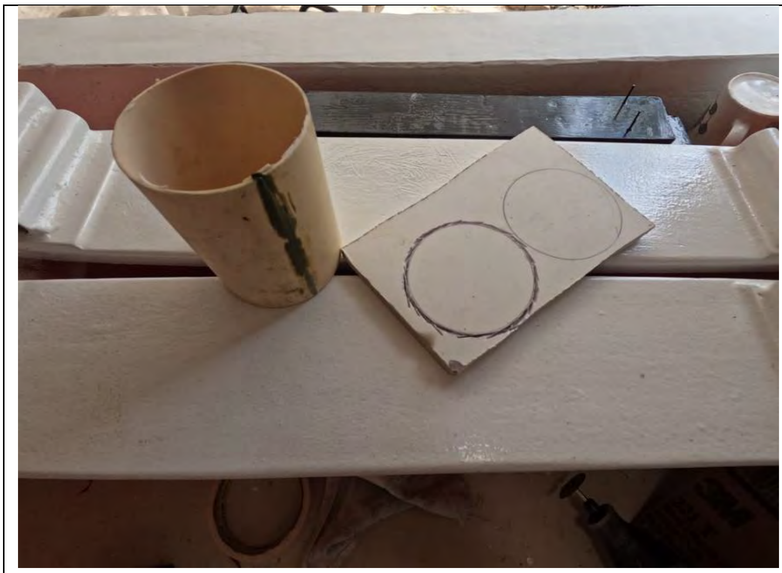


Figure 8 - The construction of the plug for the Deeper Pro probe, made of residential PVC pipe and 10 mm PVC sheet.

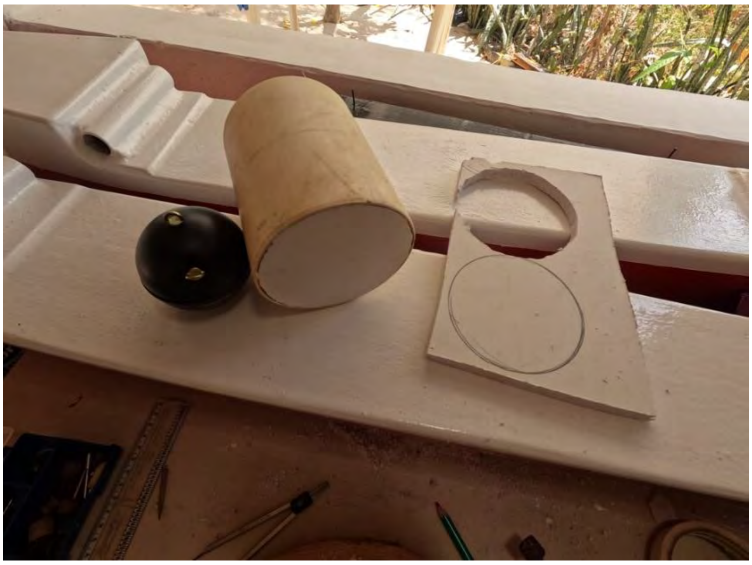


Figure 9 - The PVC plug (without perforating the base) yet, to receive the probe and 10 mm PVC sheet.

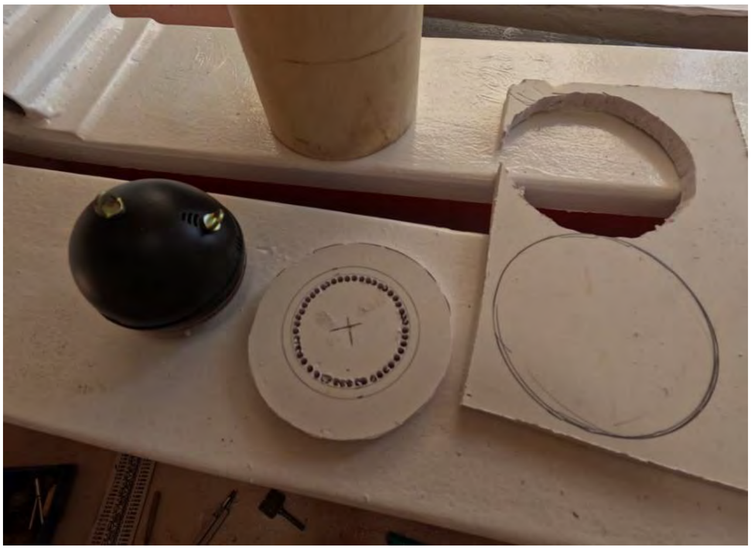


Figure 10 - Starting to adapt the plug base to receive the Deeper Pro.

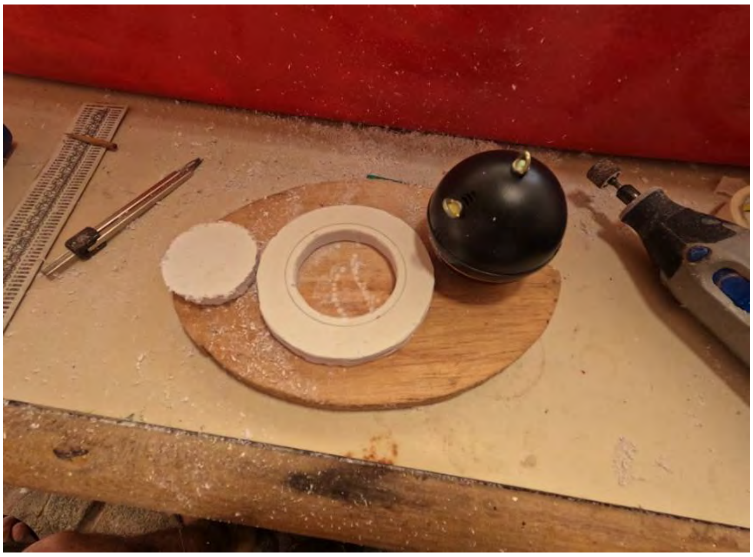


Figure 11 - Idem.

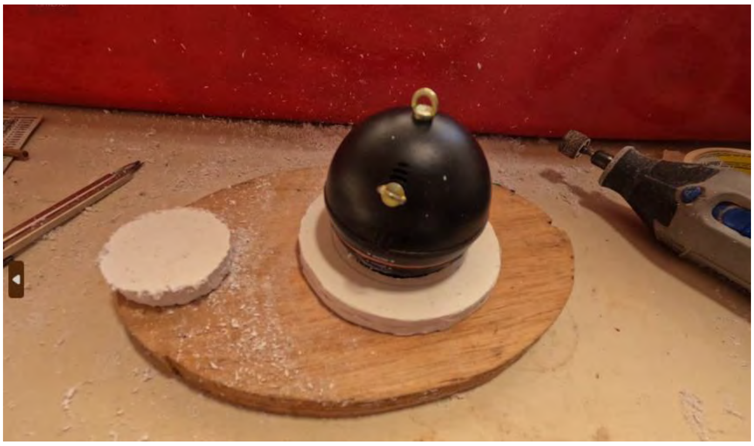


Figure 12 - Idem.

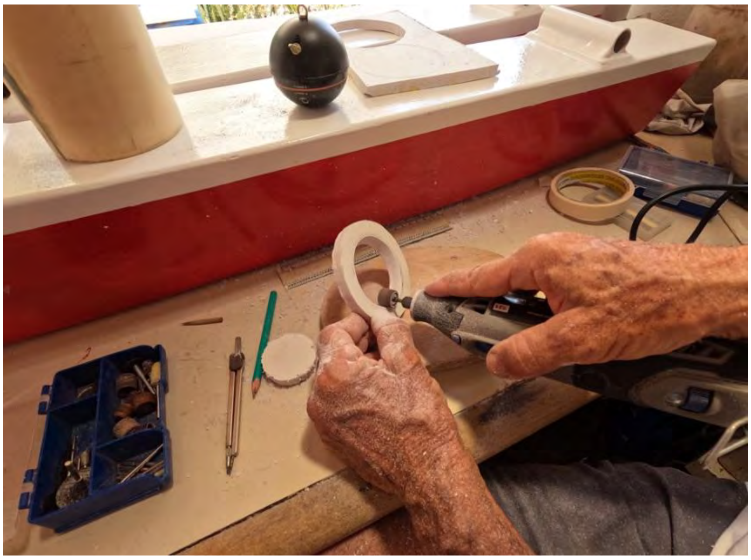


Figure 13 - Adjusting the fit of the Deeper Pro to the plug base.

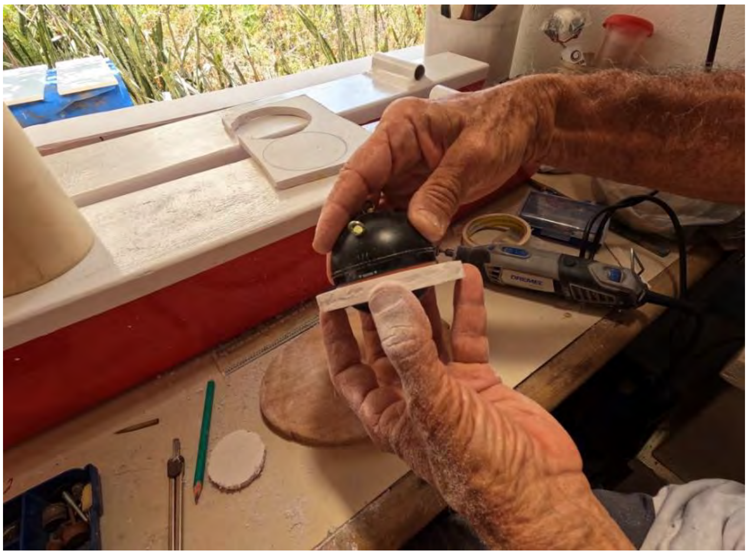


Figure 14 – The sphere fits perfectly to the base.

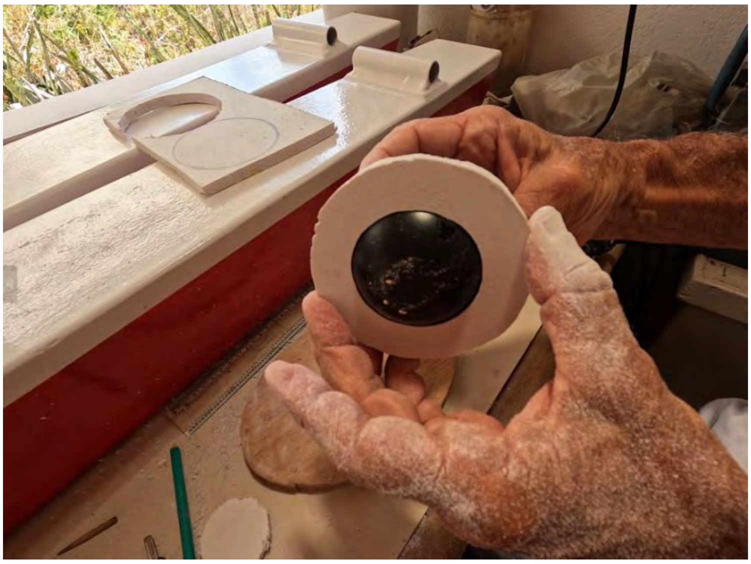


Figure 15 - Idem. It is essential that contact with water (which activates the system) is permanent.

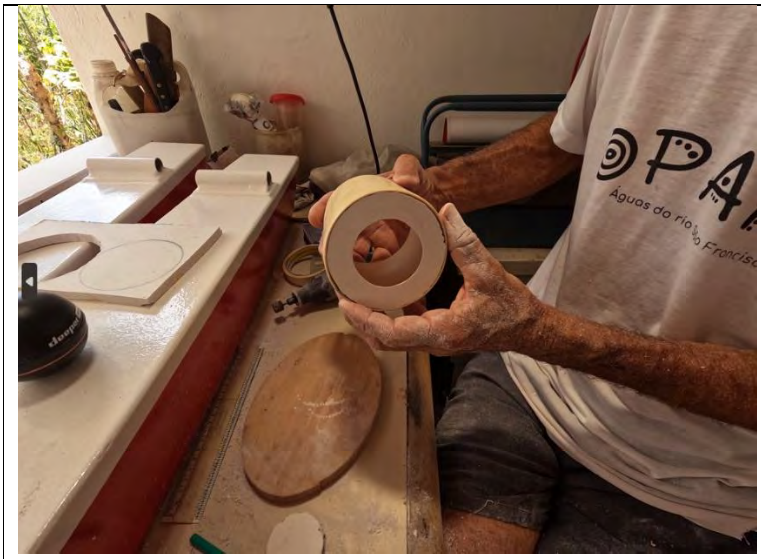


Figure 16 - Fixing the base to the plug body (100 mm PVC pipe).

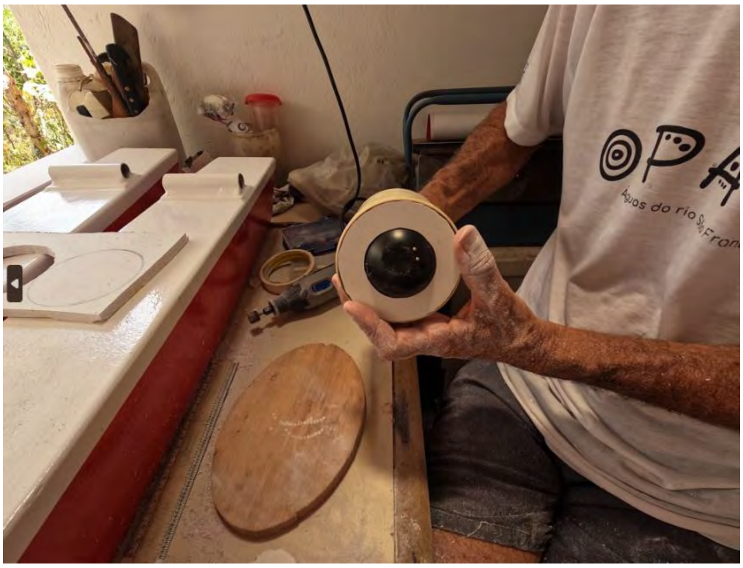


Figure 17 - Simulating assembly with Deeper Pro.

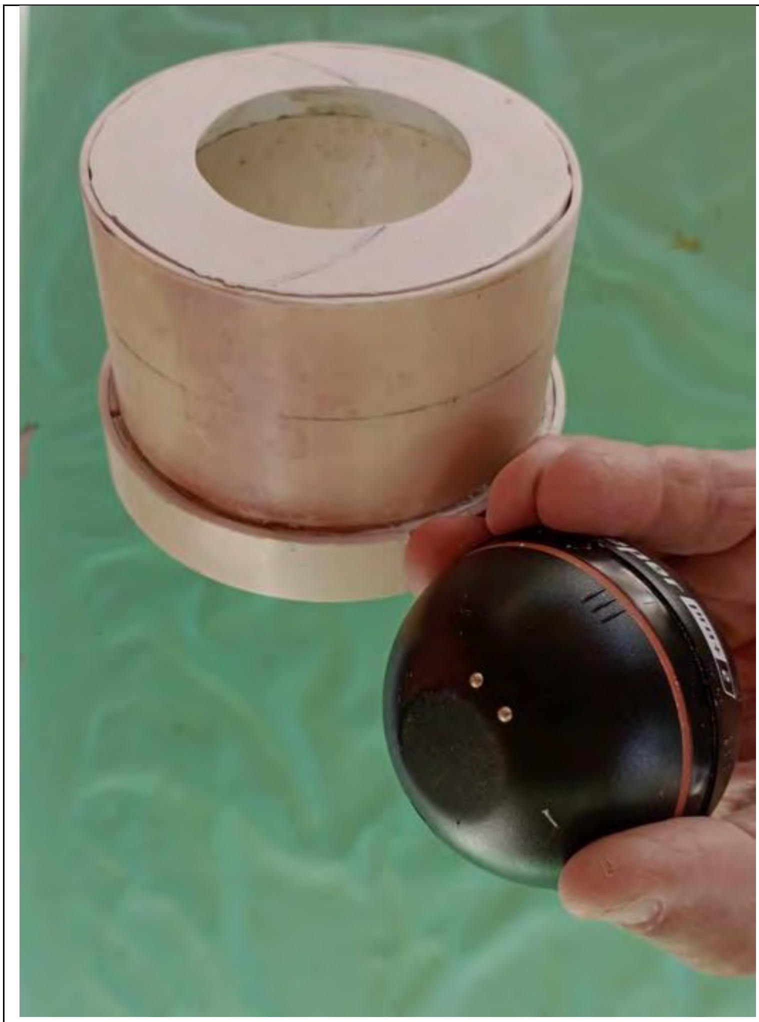


Figure 18 – The plug (unfinished) and the sonar.

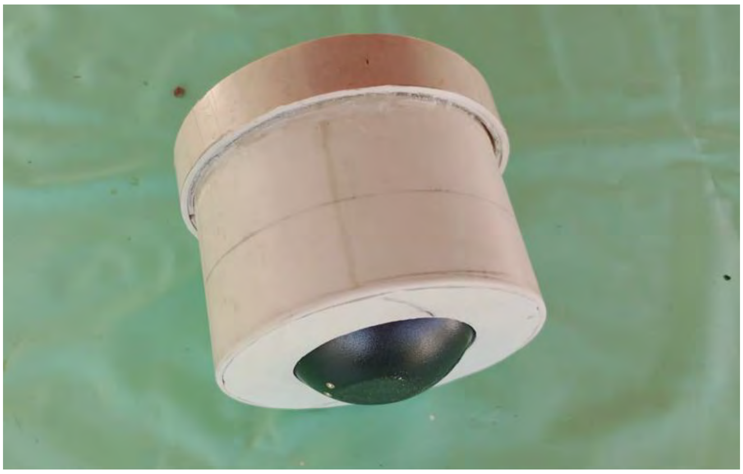


Figure 19 - Idem.

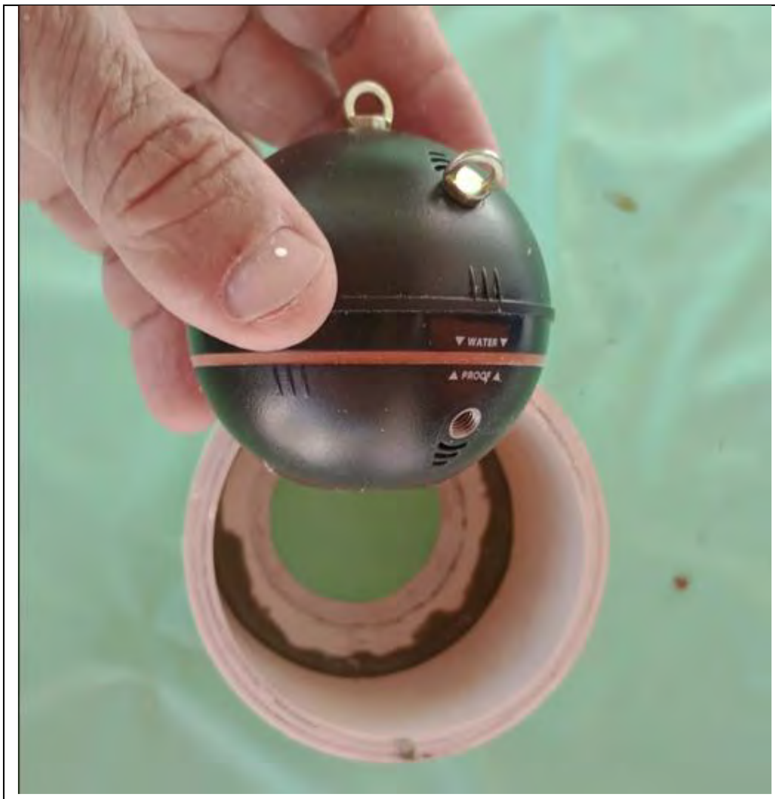


Figure 20 - The base is already glued with epoxy putty to the plug.

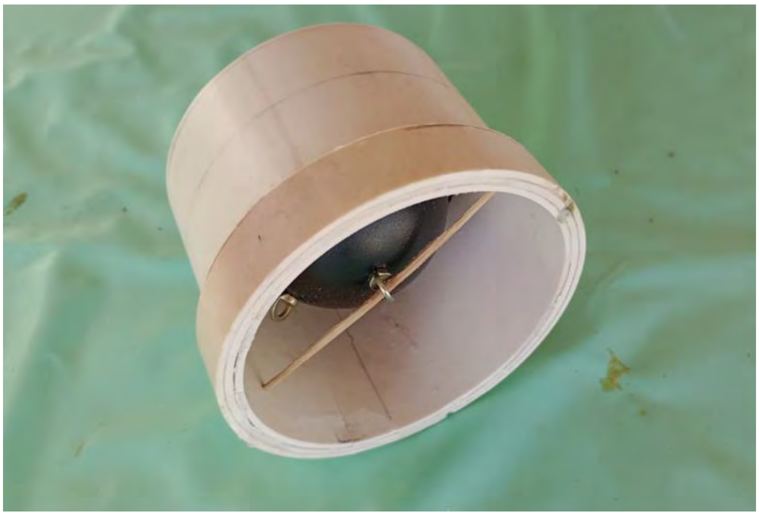


Figure 21 - Temporary shim/lock (a barbecue stick) of the probe on the plug.

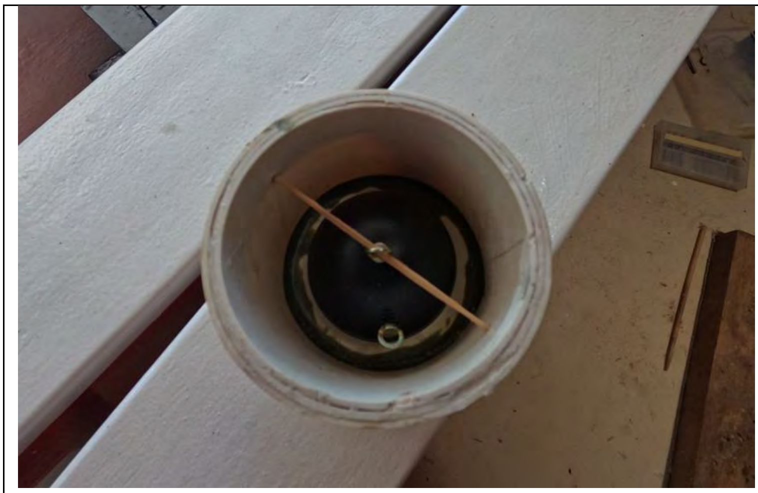


Figure 22 - Idem.

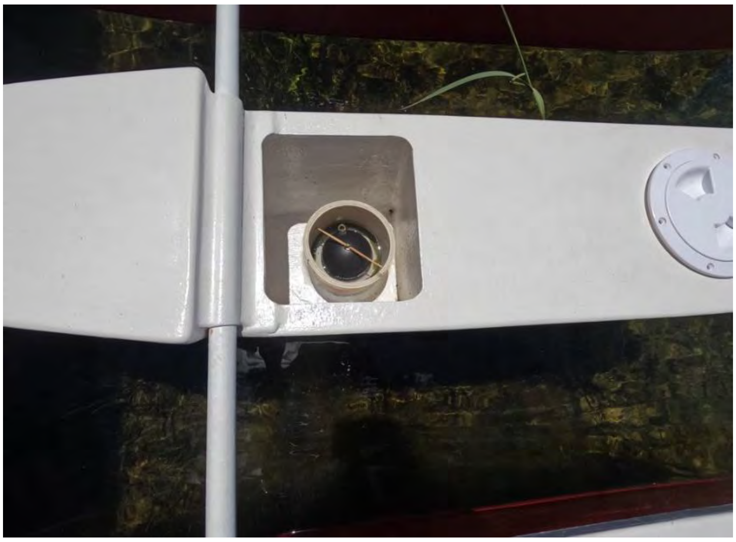


Figure 23 - Idem, on the trimaran, for preliminary system implementation/communication tests.

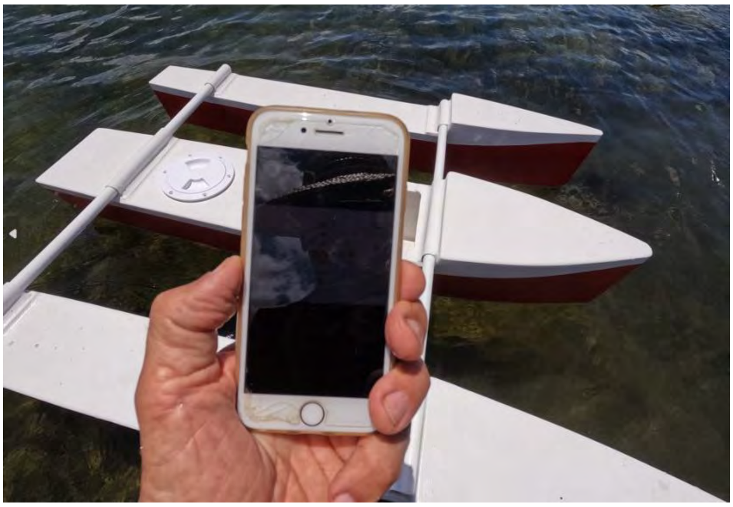


Figure 24 - Idem. Communication (perfect) established between probe and control device (cell phone).

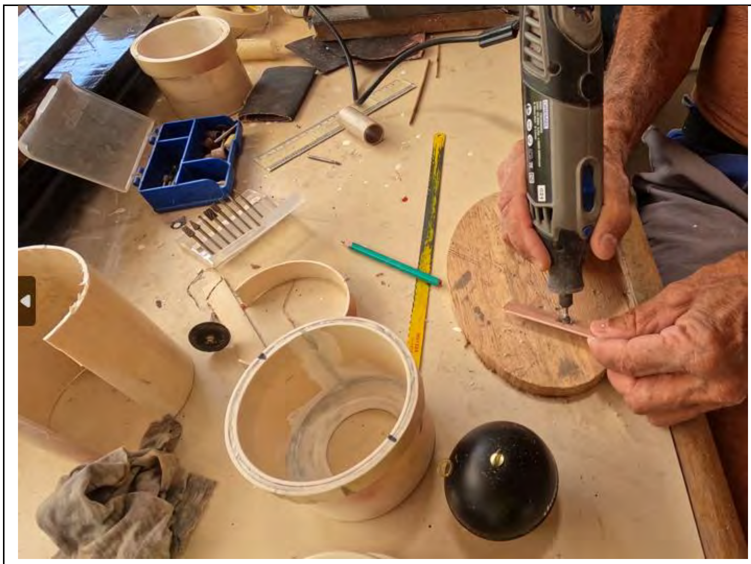


Figura 25 - Evolution of the sonar locking system. Strip of PVC pipe replaces the bamboo stick.

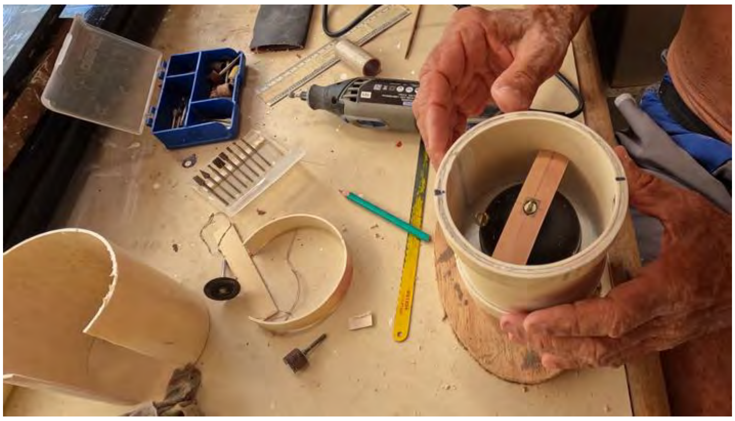


Figure 26 - Idem.

5. Universal base on trimaran deck

Envisioning the use of other monitoring systems, particularly GPS/RTK for measuring the slope of watercourses and/or monitoring the bathymetry data collection route, a universal base was designed on the trimaran's deck.

The base will serve as a dock for various equipment on the trimaran: antennas, cameras, LIDAR systems, etc.

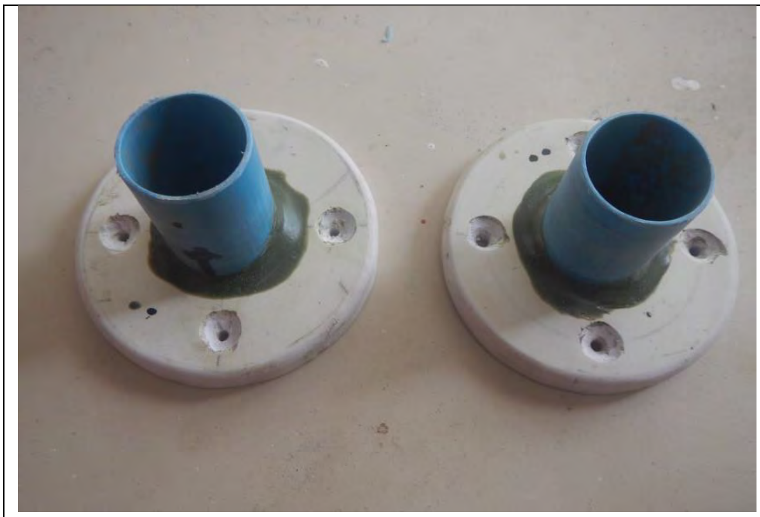


Figure 27 - Multi-use bases for installing various equipment. 10 mm PVC plate and 32 mm PVC pipe.

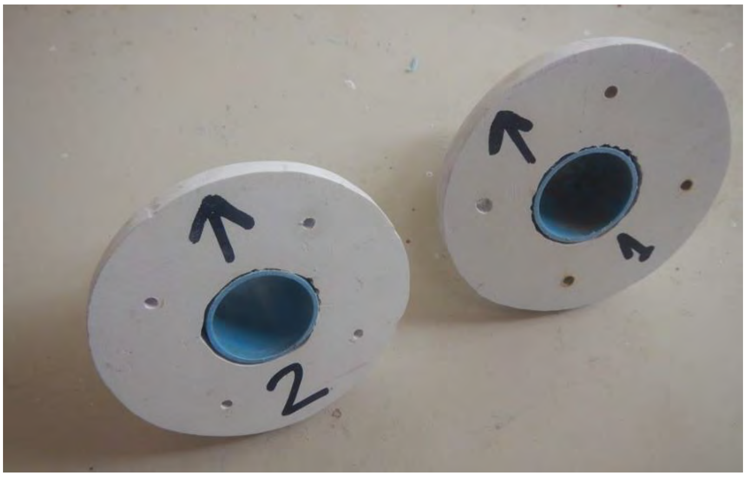


Figure 28 - Idem.

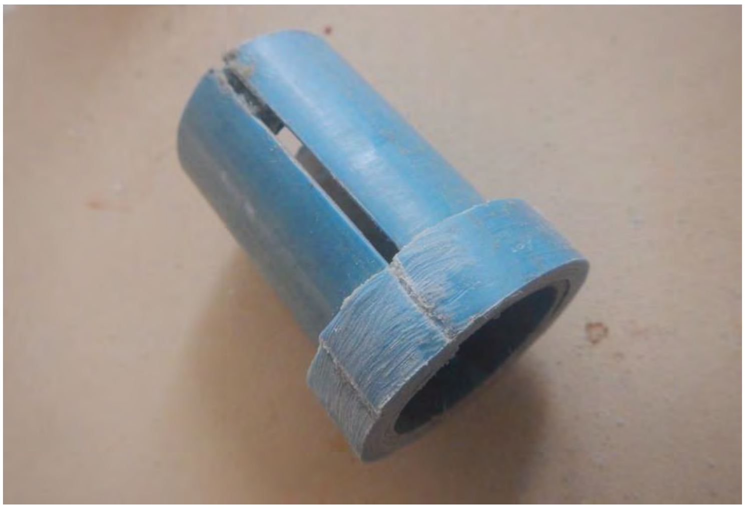


Figure 29 - Plug-in plug for installing the magnetic base of the ROVER antenna (GPS/RTK). PVC tube 32 mm.

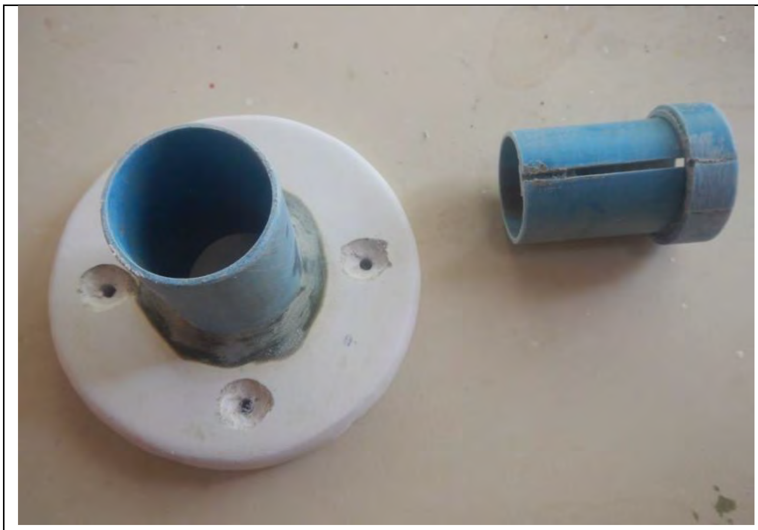


Figure 30 - Idem.

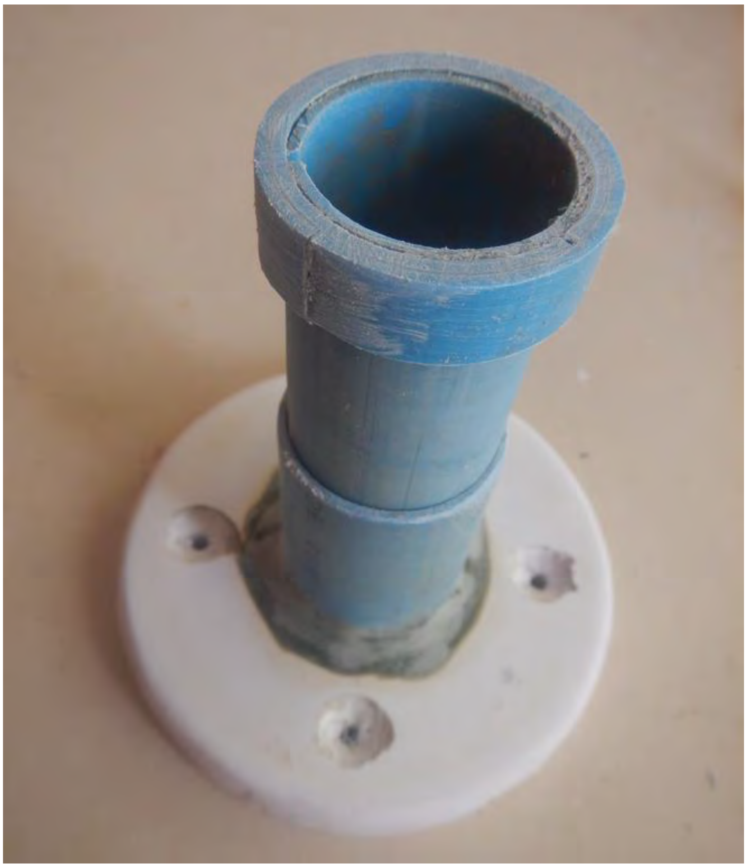


Figure 31 - Idem.

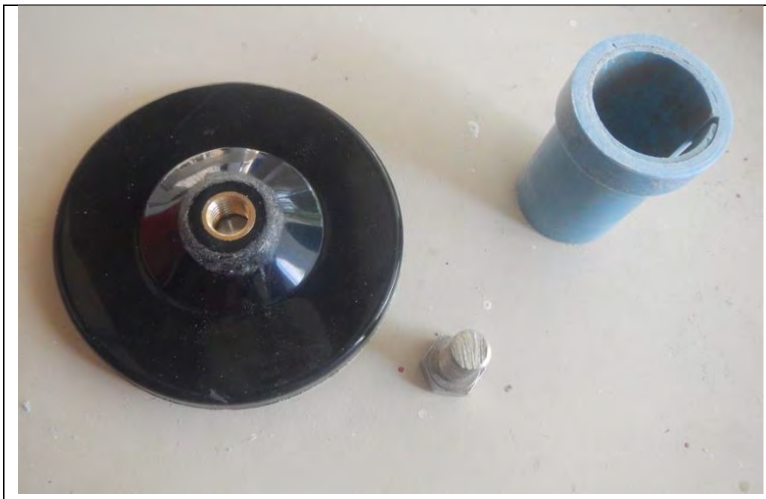


Figure 32 - Magnetic base for fixing the GPS/RTK antenna (Rover).

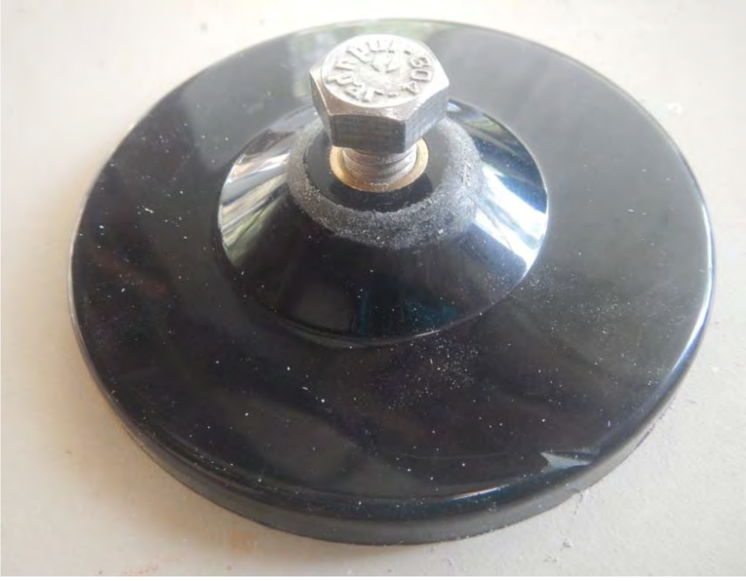


Figure 33 - 3/8 stainless steel bolt that will be used in the base fixing plug.

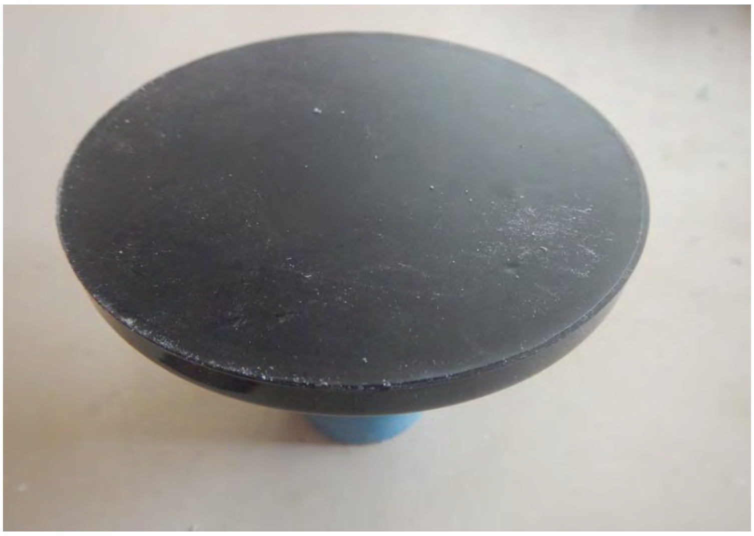


Figure 34 - Simulation of the base installed over the plug.

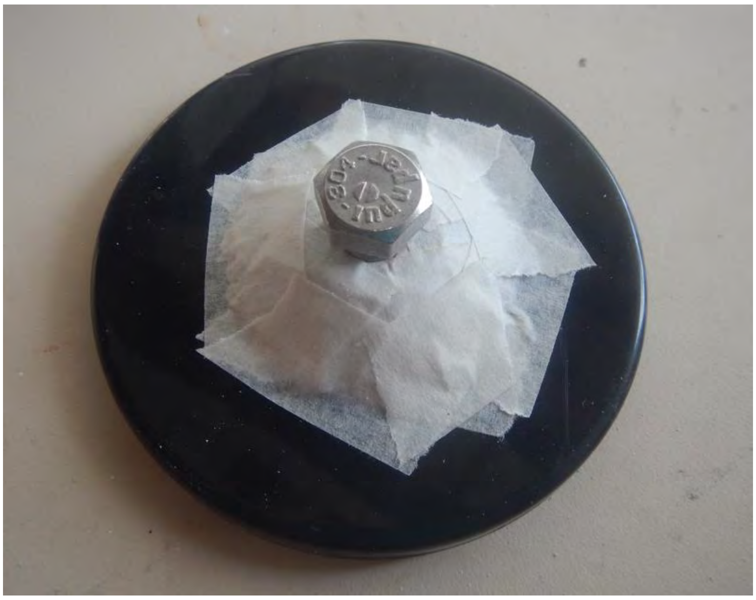


Figure 35 - Preparation for gluing/molding the screw to the plug. Painting tape to permit unmolding.

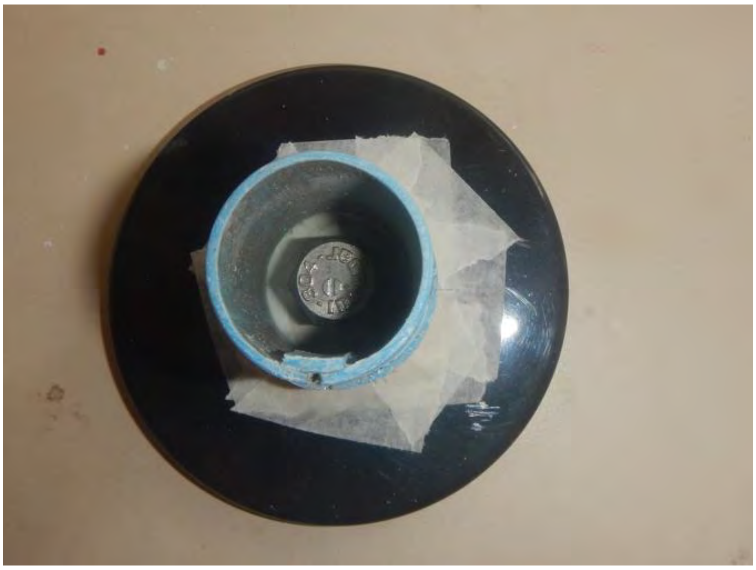


Figure 36 – Temporary installation of the plug on the base for gluing with epoxy putty.

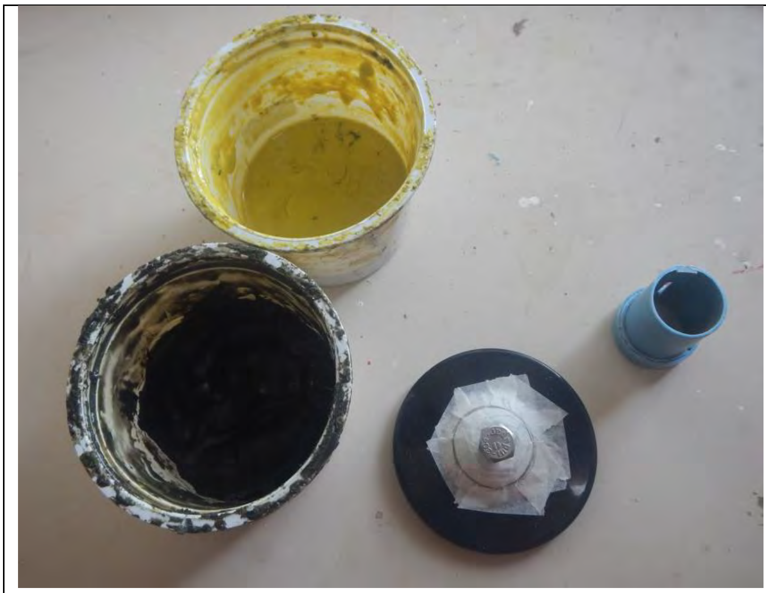


Figure 37 - Bonding the bolt to the plug with MEP 301 epoxy putty.

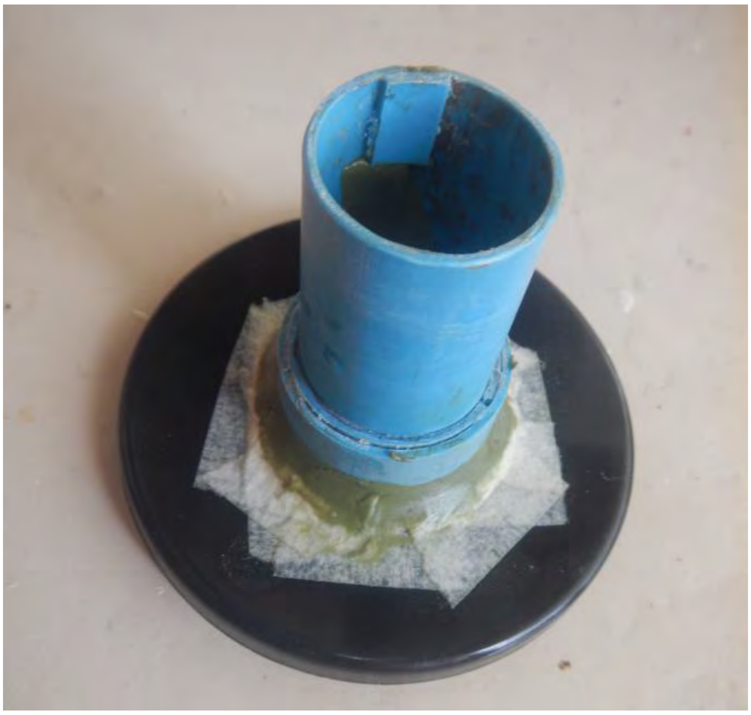


Figure 38 - Idem.

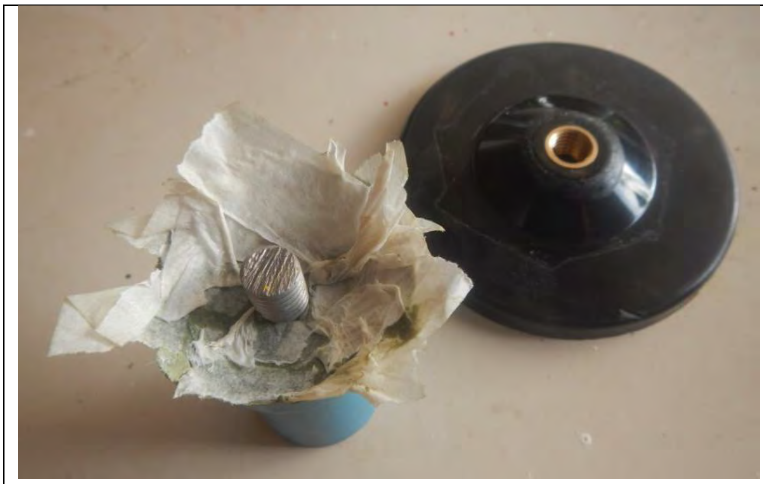


Figure 39 – Plug molding. Insulation tape still to be removed.

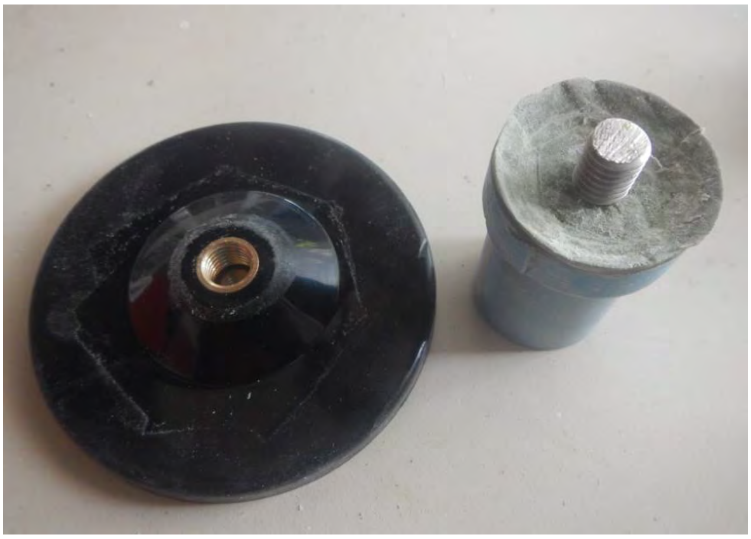


Figure 40 - Pre-finishining the cured epoxy, bolt cast to the plug.

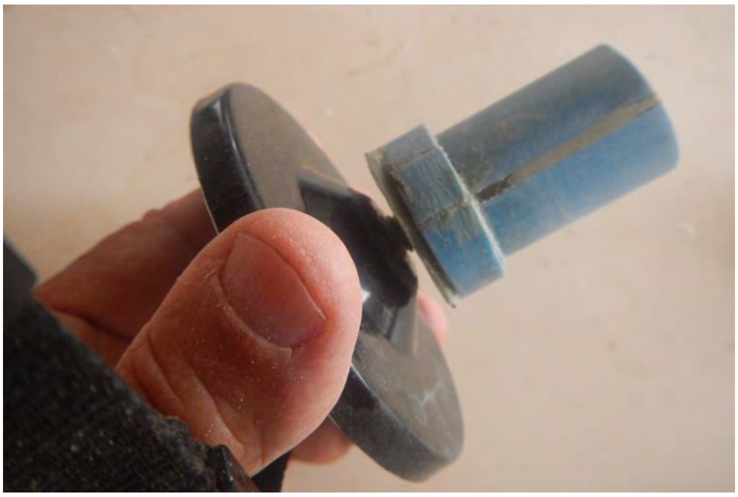


Figure 41 – Testing the assembly of the plug to the base.

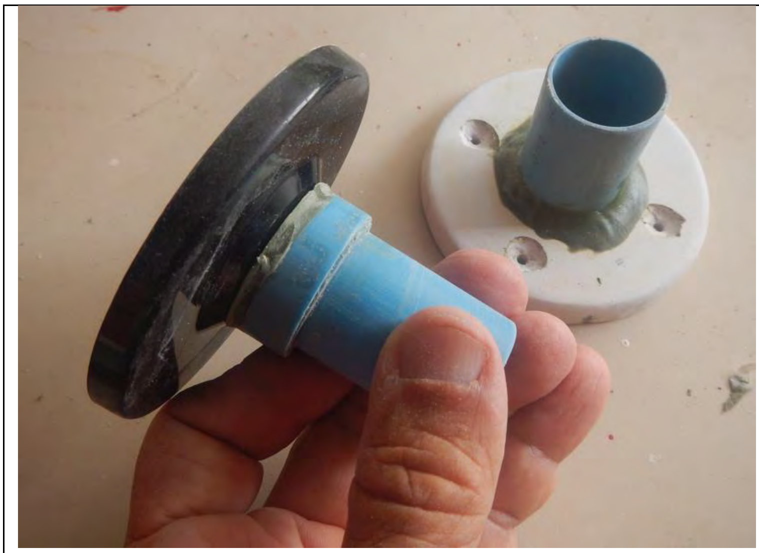


Figure 42 - Idem.

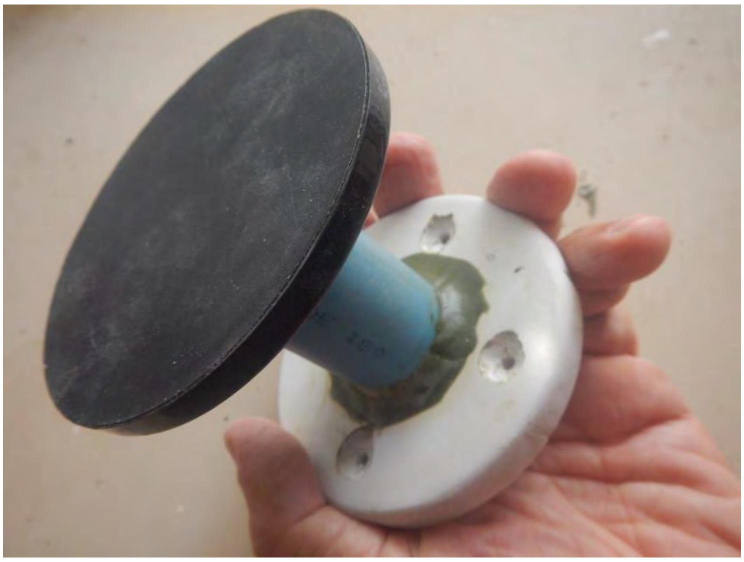


Figure 43 - Idem. Assembly mounted at the base of the deck.

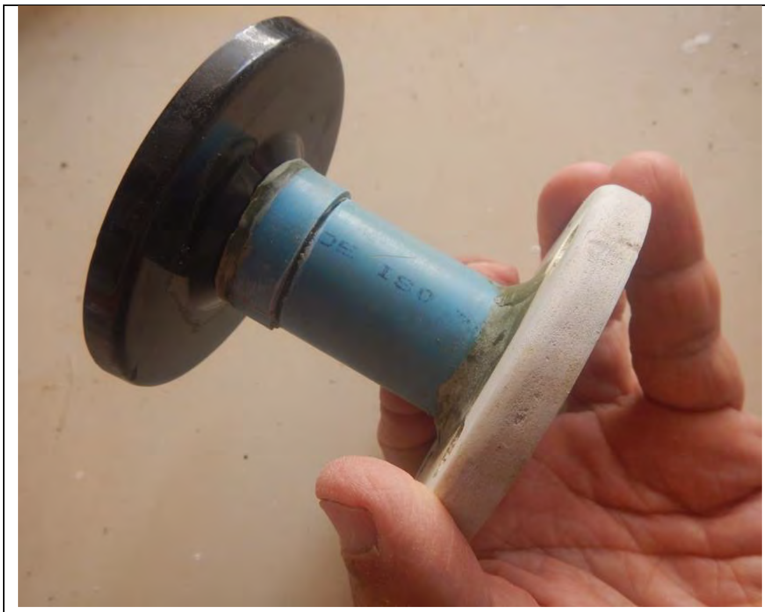


Figure 44 - Idem.

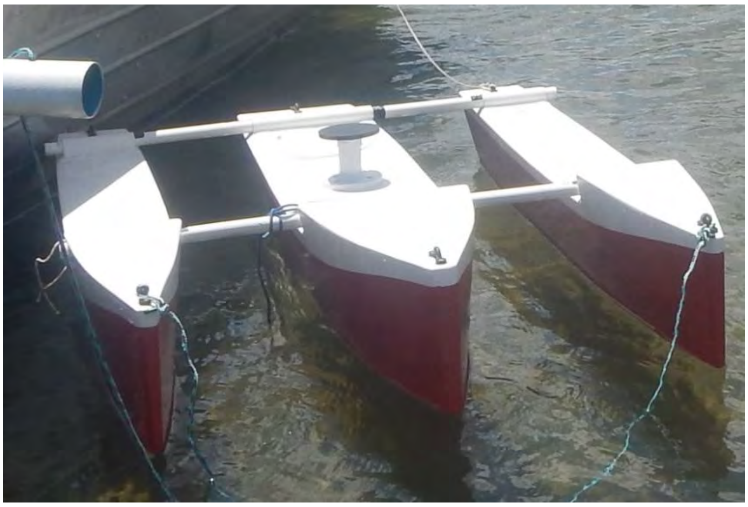


Figure 45 - Idem. **Final assembly on the trimaran (during first tests).**

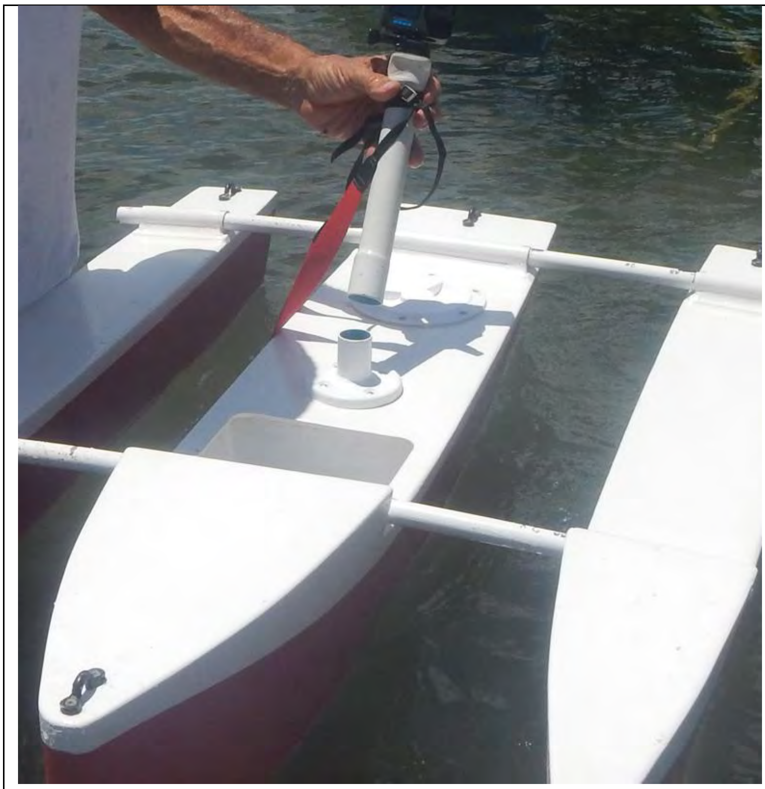


Figure 46 - Alternative mounting. Photo/video camera.

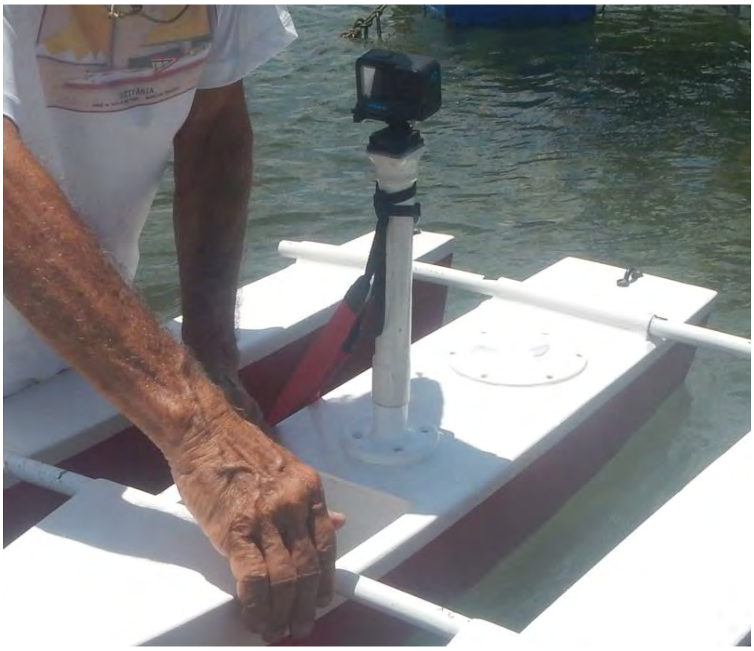


Figure 47 - Idem.

6. Sea trials

On January 14th, the first navigation tests were carried out with the monitoring trimaran prototypes.

The vessel was configured for bathymetry operations, with only the Deeper Pro probe on board.

As a reference, the trimaran's design displacement is 13 (thirteen) kg.

The ripples on the river were in the order of 100 to 200 mm, light winds. The test consisted of several runs (along a section of the riparian zone of the Mato da Onça Reserve, around 400 m each leg) with the wind, E (against the current) and against the wind (with the current).

Main target

observe the vessel's behavior under bathymetry working conditions.

Specific objectives

a) Observe and analyze the vessel’s course stability;
b) Observe and analyze the transverse stability of the vessel;
c) Observe and analyze the behavior of the vessel when passing waves (for and against);
d) Observe and analyze the waves generated by the dragging of the hulls;
e) Observe and analyze the wake generated by the hulls;
f) Observe and analyze the vessel's behavior when maneuvering turns (returning course);
g) Observe and analyze the communication between the Deeper Pro system and the control device;
h) Observe and analyze the stability of the Deeper Pro signal;
i) Observe and analyze any anomalies that may arise.

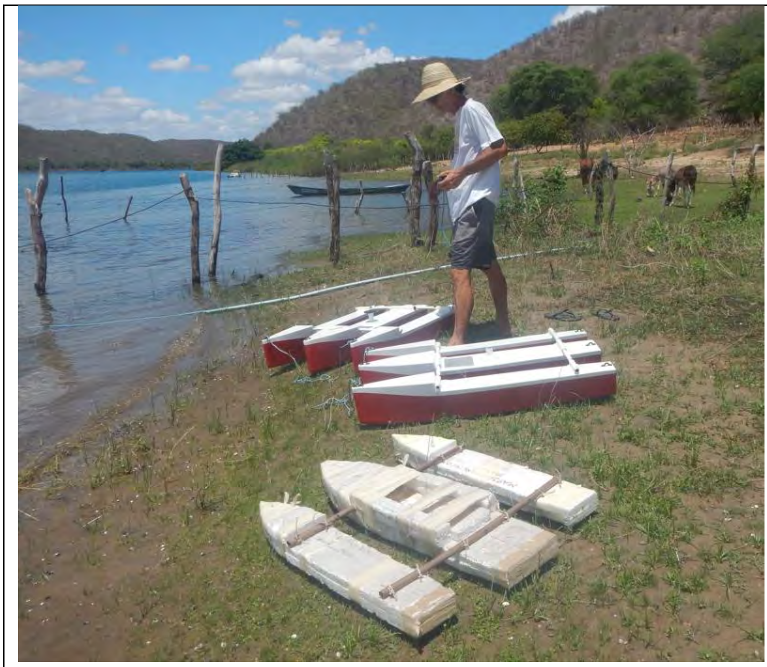


Figure 48 - Final assembly of prototypes at the water's edge. In the foreground, the conceptual pre-prototype used in 2022.

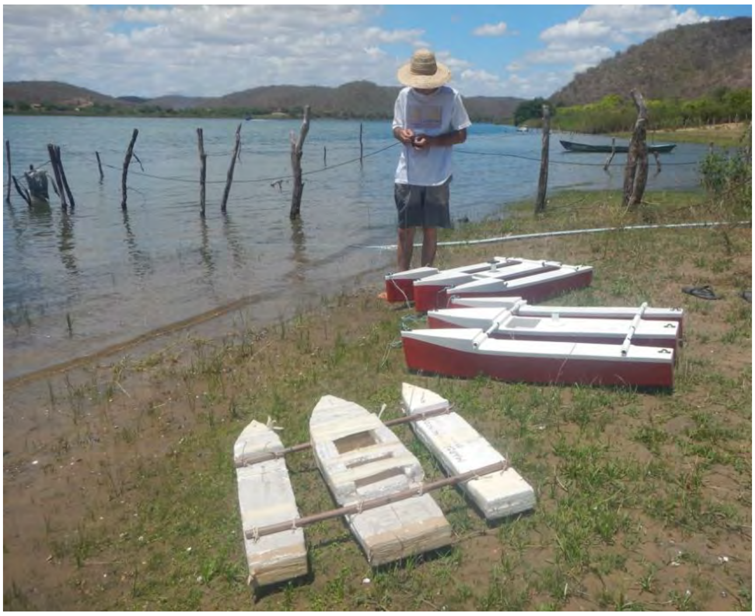


Figure 49 - Idem.

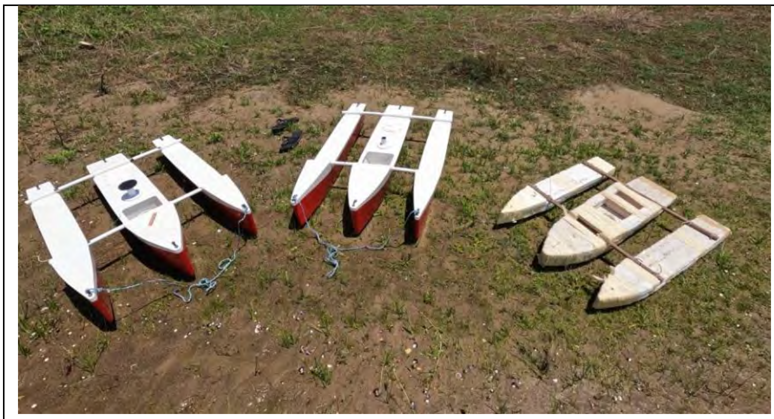


Figure 50 - Idem. Note that both prototypes have their temporary connecting beams, made of 20 mm PVC tube and not aluminum as expected.

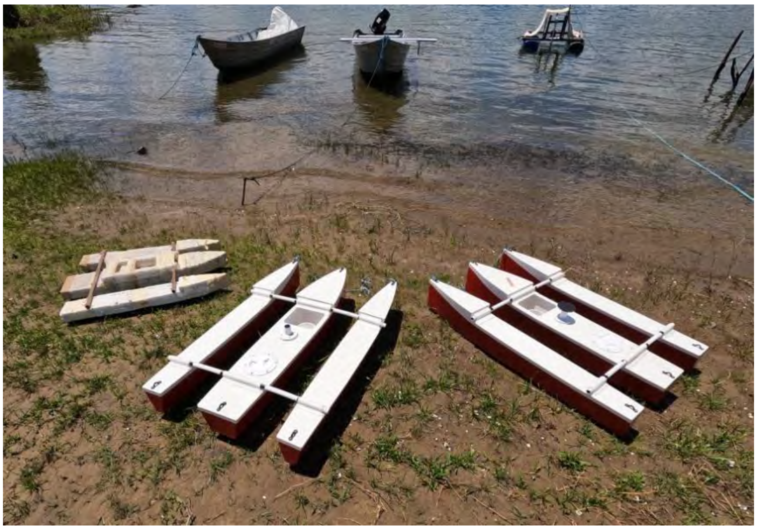


Figure 51 - Idem.

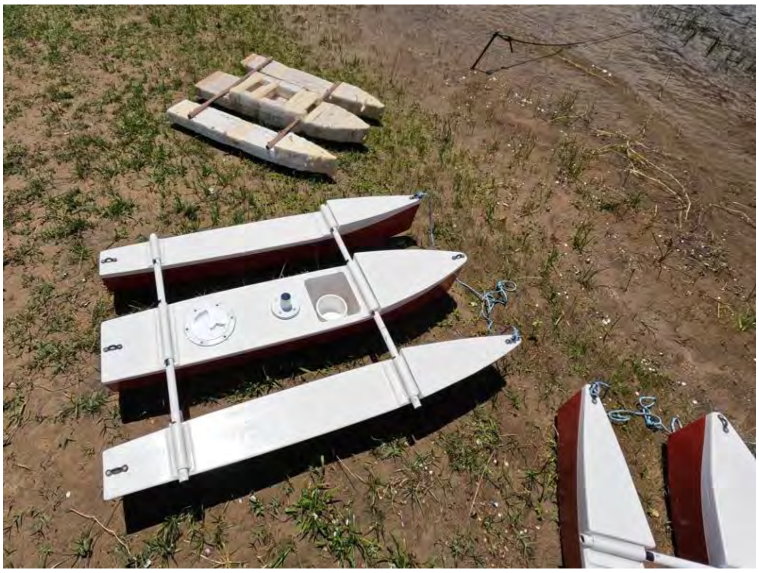


Figure 52 - Idem.

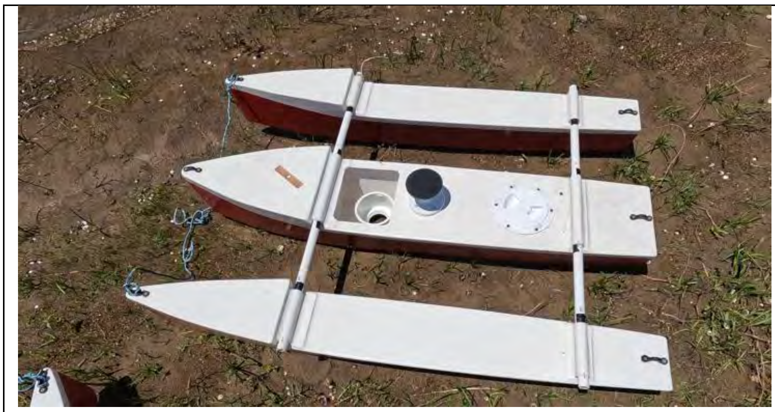


Figure 53 - Idem. Note the magnetic base for the GPS/RTK antenna.

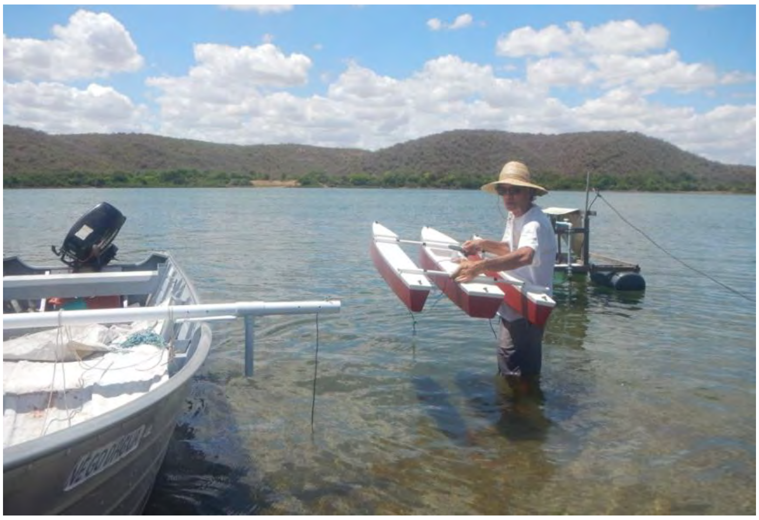


Figure 54 - Assembling the equipment on one of the vessels. Note the trimaran's towing system, made of 50 mm PVC pipe.

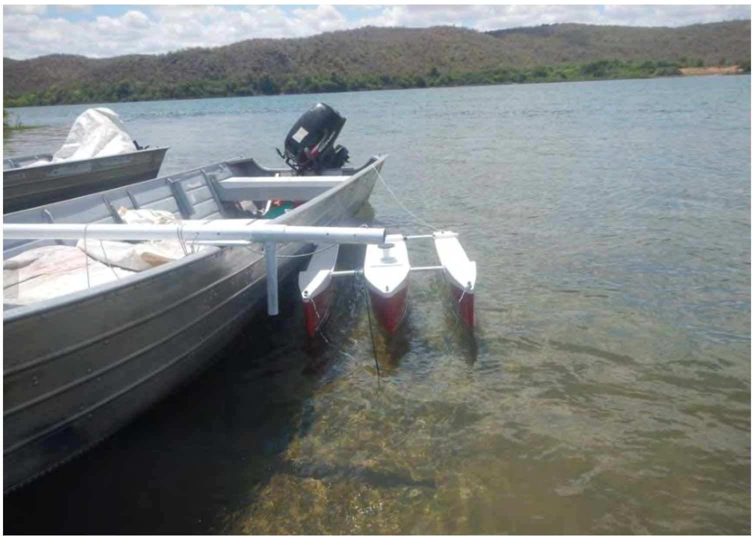


Figure 55 - Trimaran mounted on towing system. Stern cable to control the vessel's distance and contain acceleration when sailing in favor of the waves.

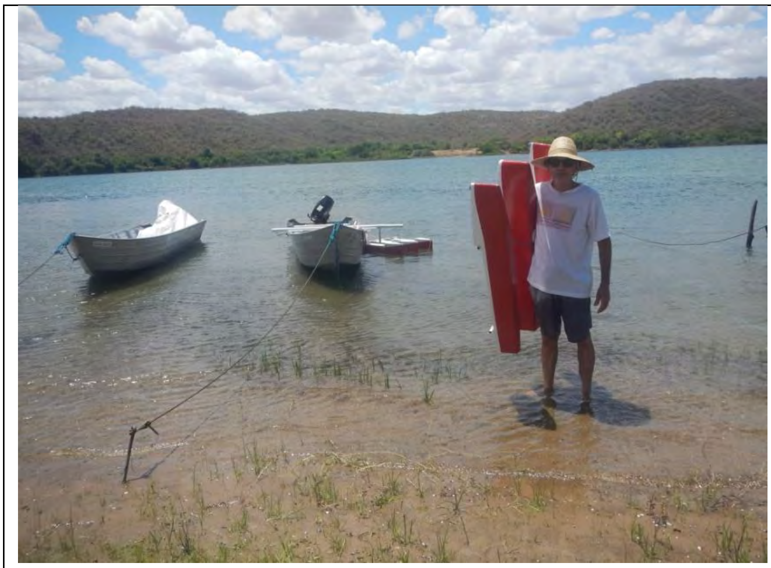


Figure 56 - The set is lightweight and easy to transport when assembled.

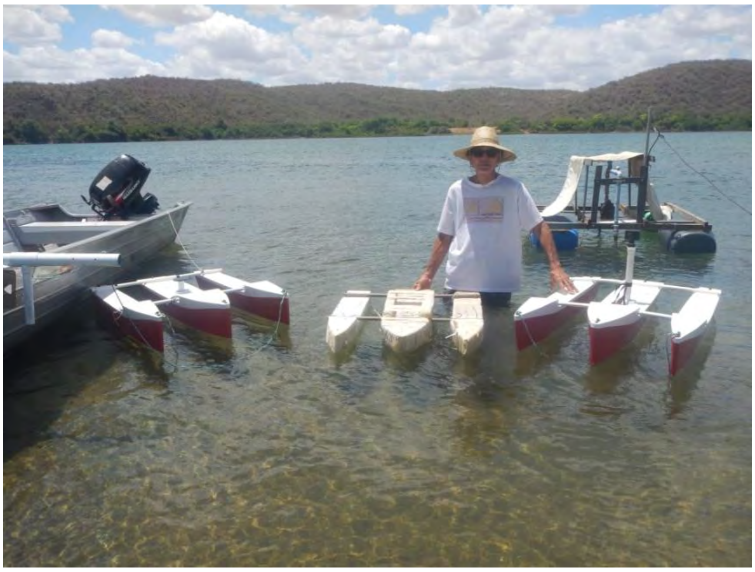


Figure 57 - Last photo of current trimarans with their precursor before dismantling and disposal.

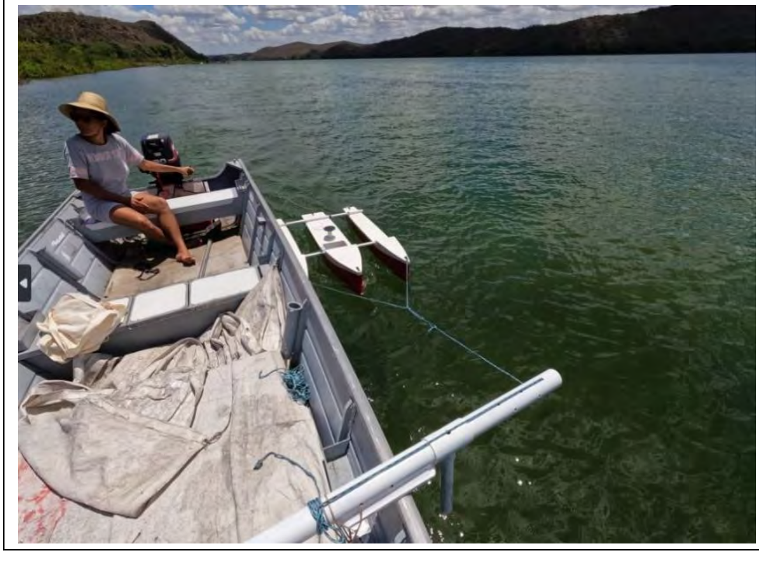


Figure 58 - Navigating and initial adjustments of tow lines, halter, stern. Leg going up the river, in favor of the waves.

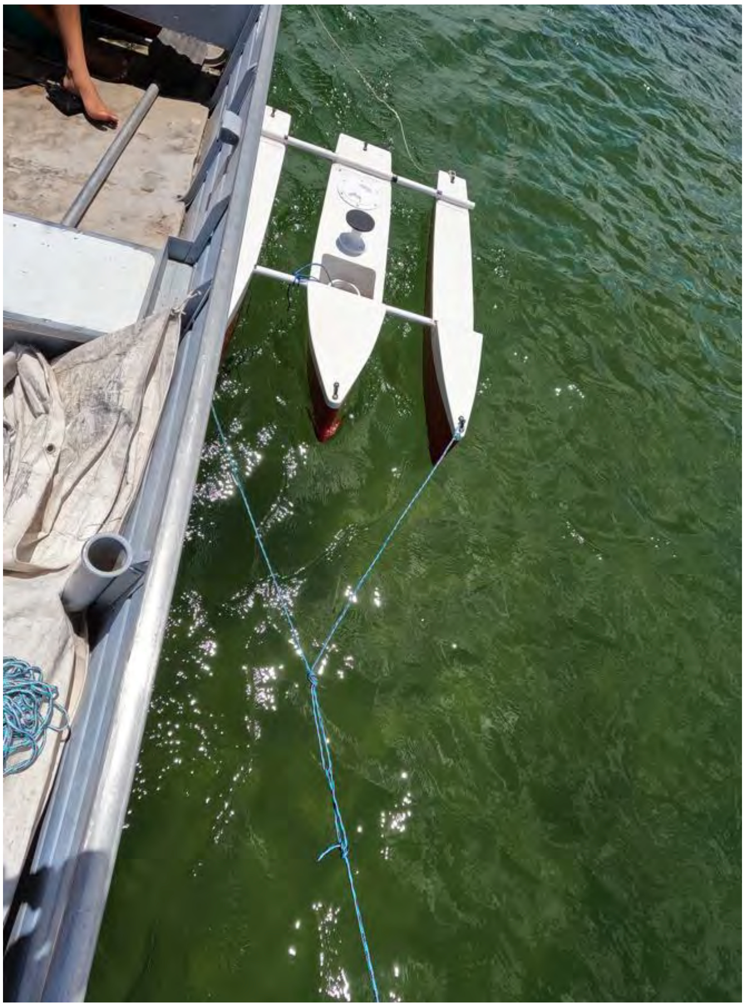


Figure 59 - Idem. Perfect.

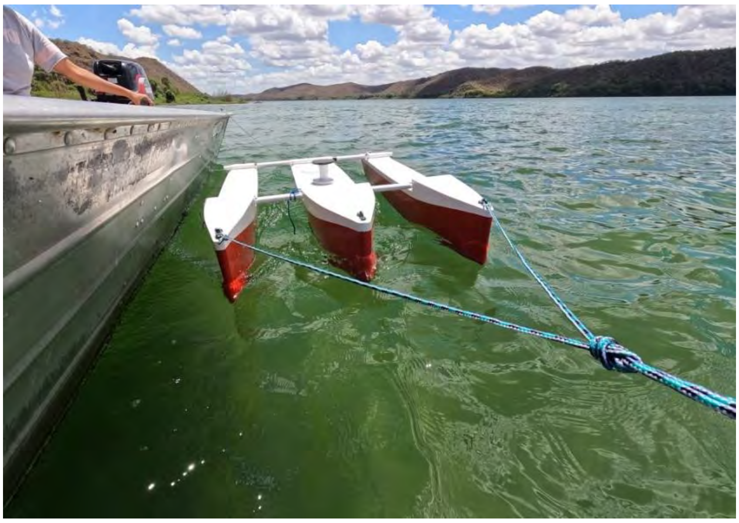


Figure 60 - Idem.

Figure 61 - Deeper Pro/device communication 100%.

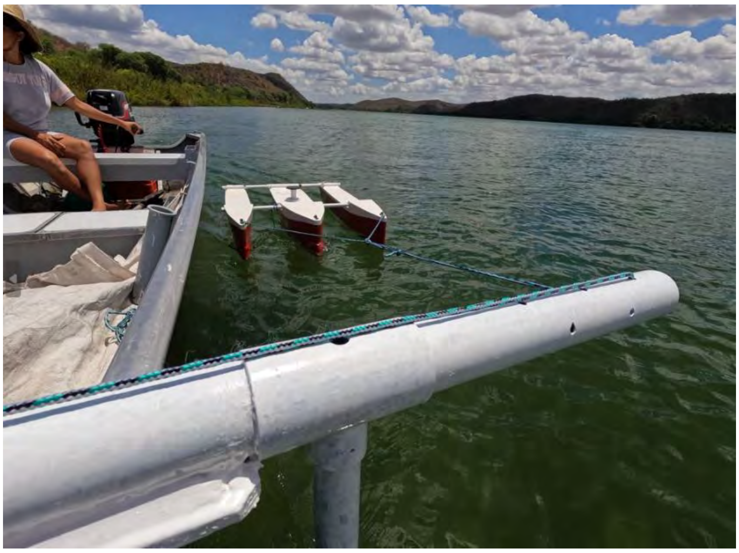


Figure 62 - Sailing against the current, with the waves.

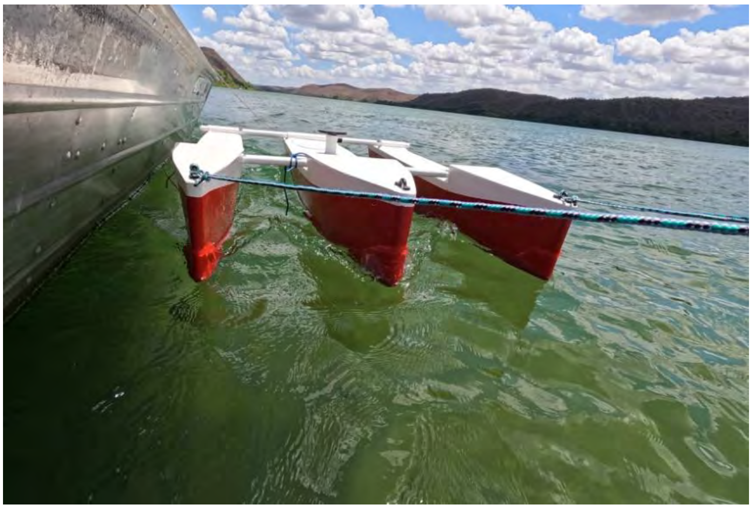


Figure 63 - Idem.

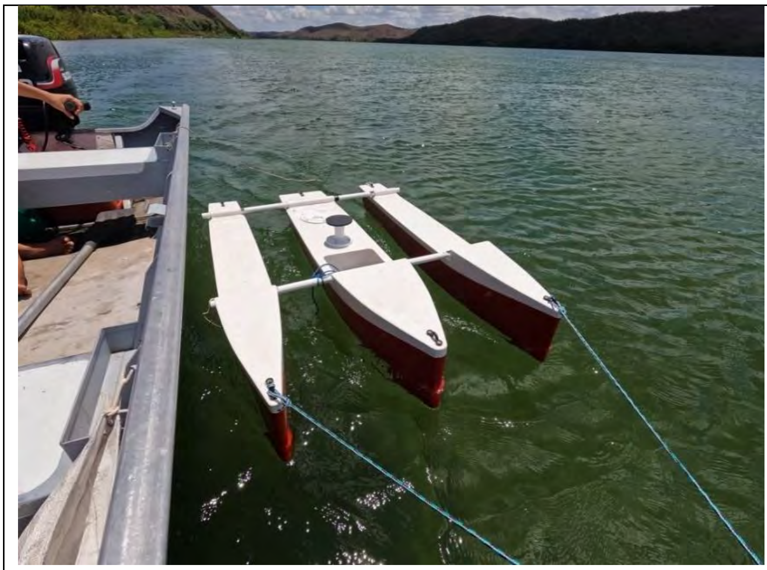


Figure 64 - Idem.

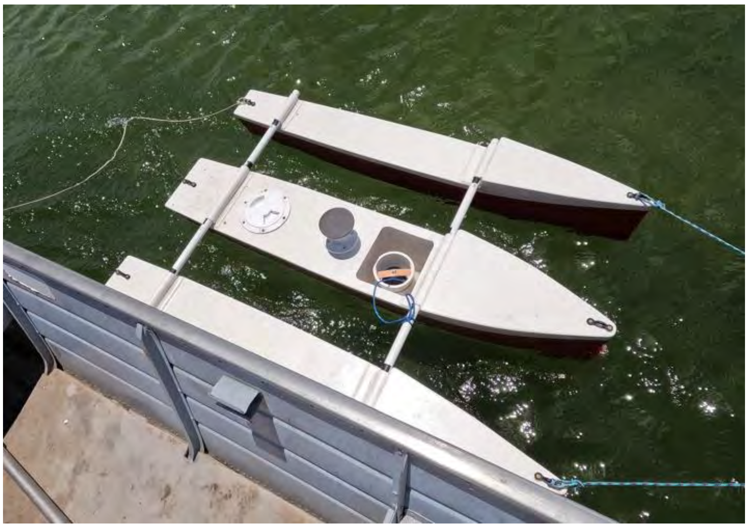


Figure 65 - Idem. Note the installed probe, with safety line.

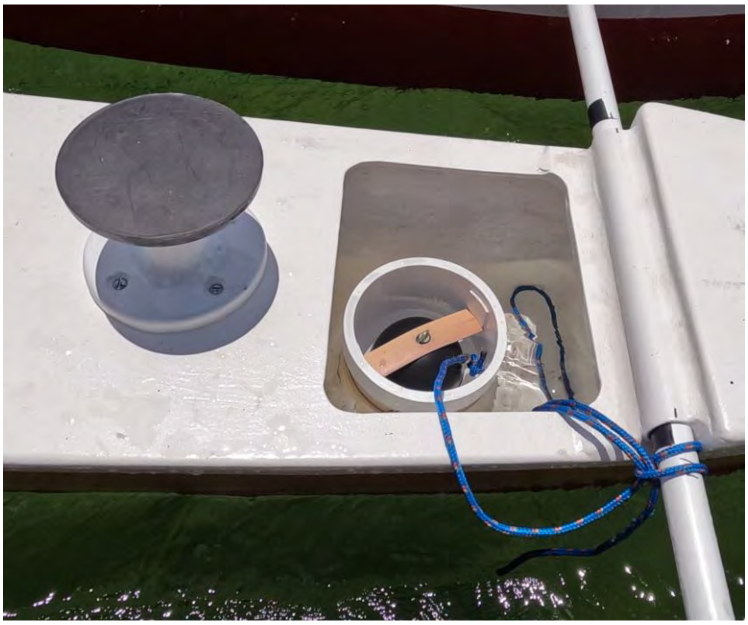


Figure 66 - Idem.

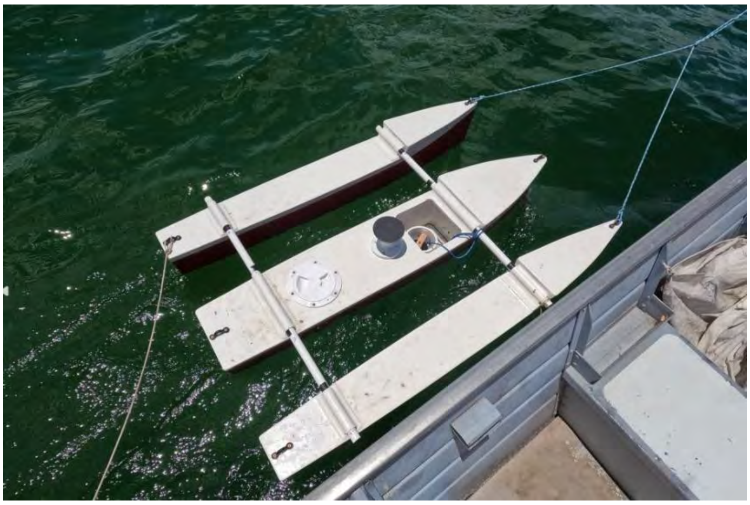


Figure 67 - Idem.

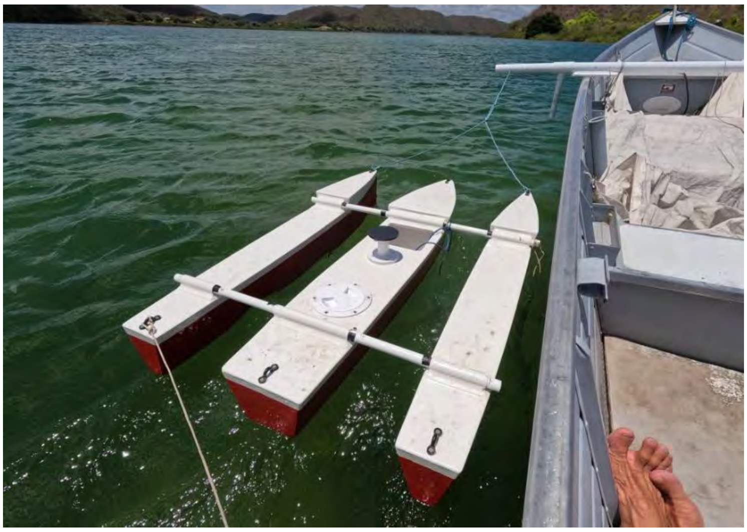


Figure 68 - Idem. Note the wake. Low drag hulls.

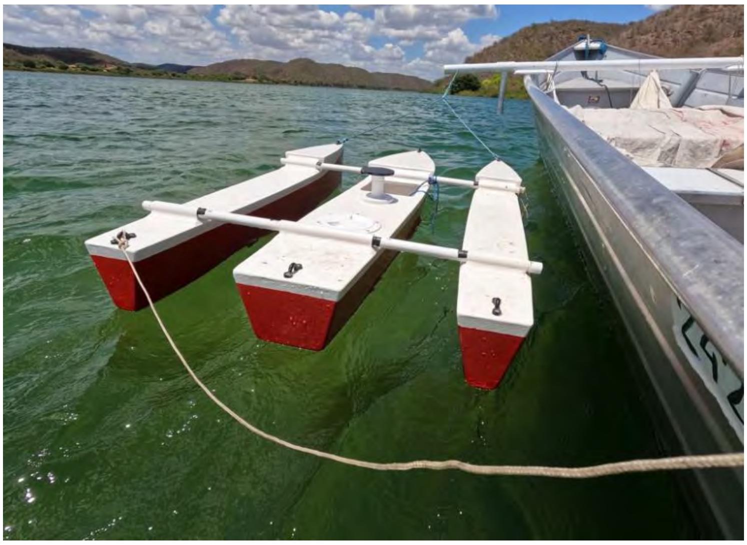


Figure 69 - Idem.

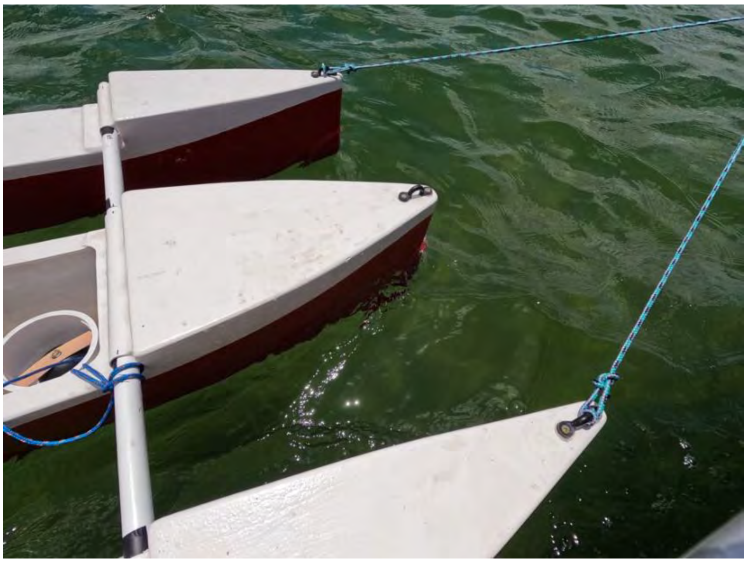


Figure 70 - Idem. Note that the high bows guarantee buoyancy reserve when passing waves.

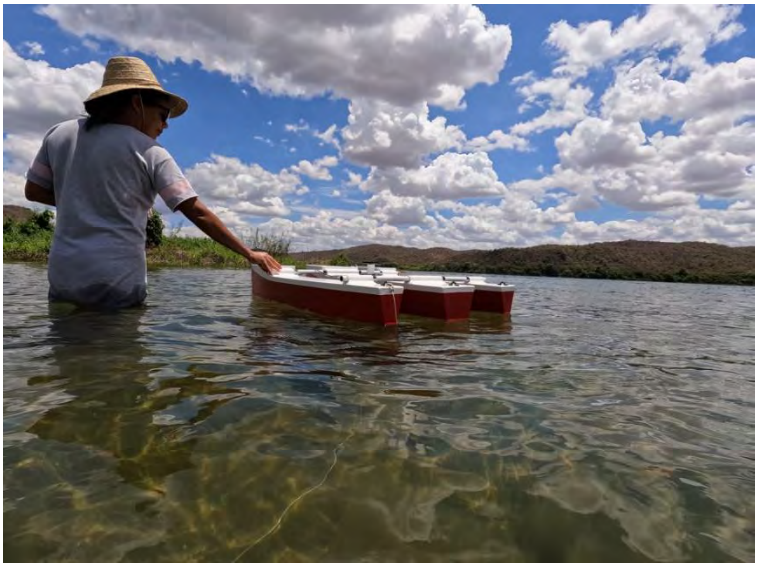


Figure 71 - Finishing static tests.

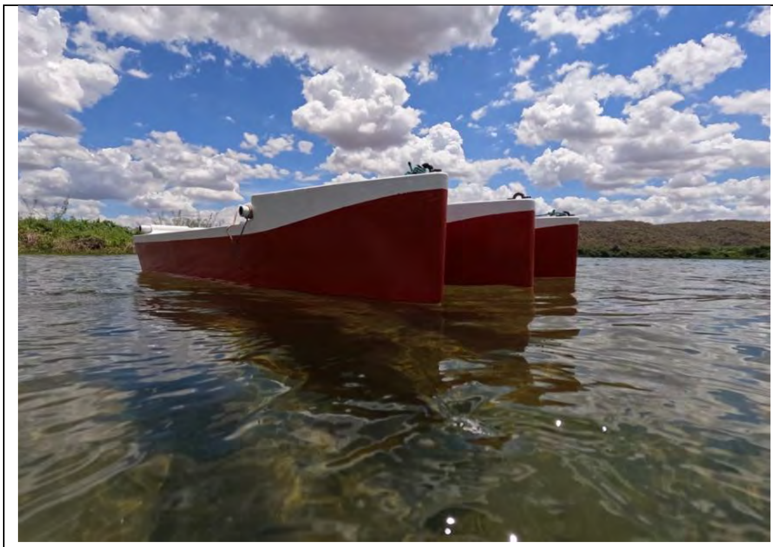


Figure 72 - The trimaran is perfectly seated, level, on its expected waterlines in lightweight condition.

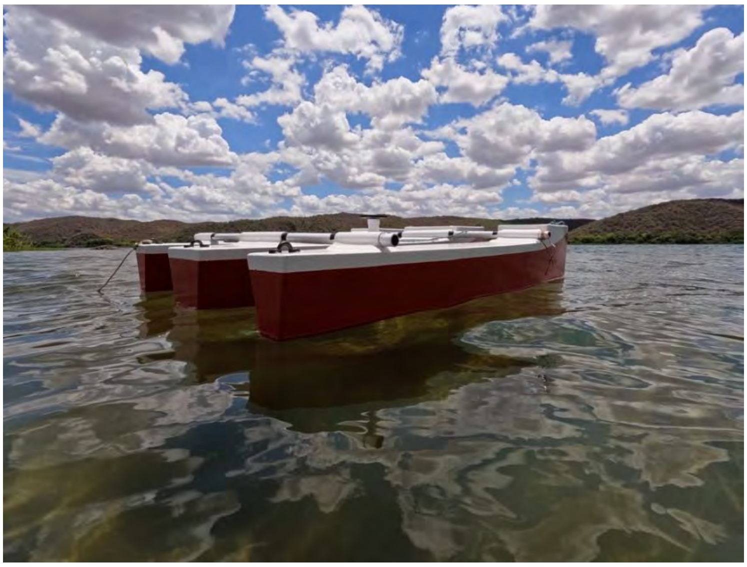


Figure 73 - Idem.

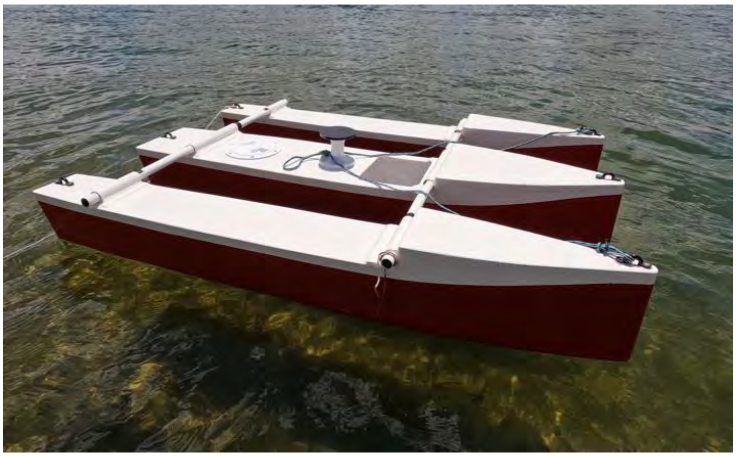


Figure 74 - Idem.

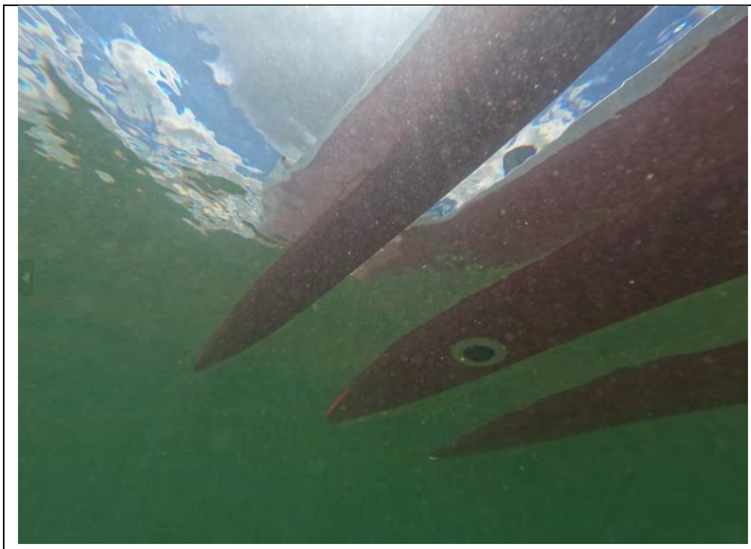


Figure 75 - Under the waters, the view of fish. The Deeper probe in its interchangeable plug.

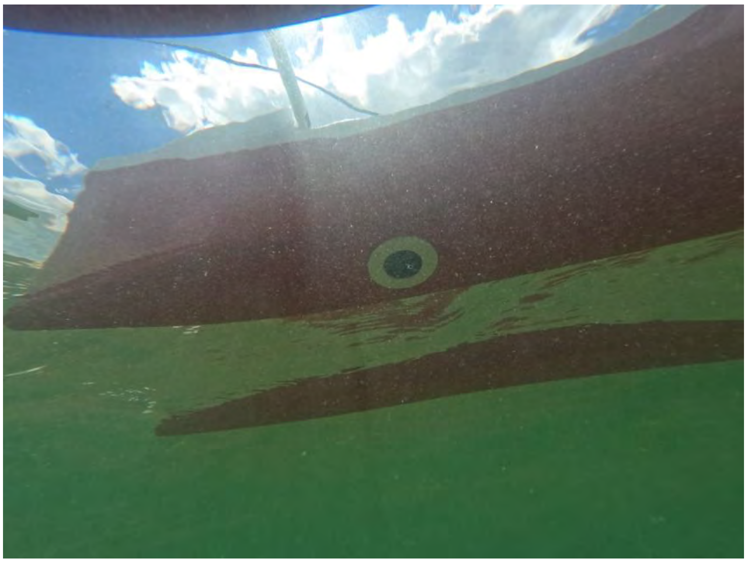


Figure 76 - Idem.

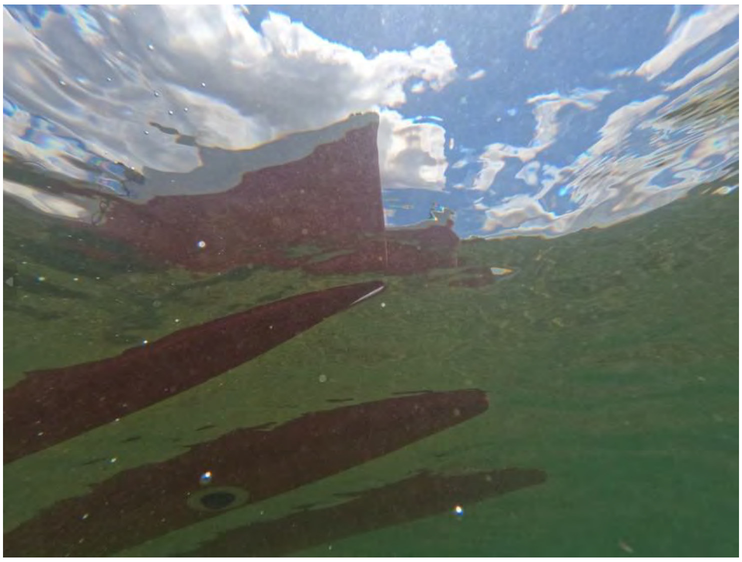


Figure 77 - Idem.

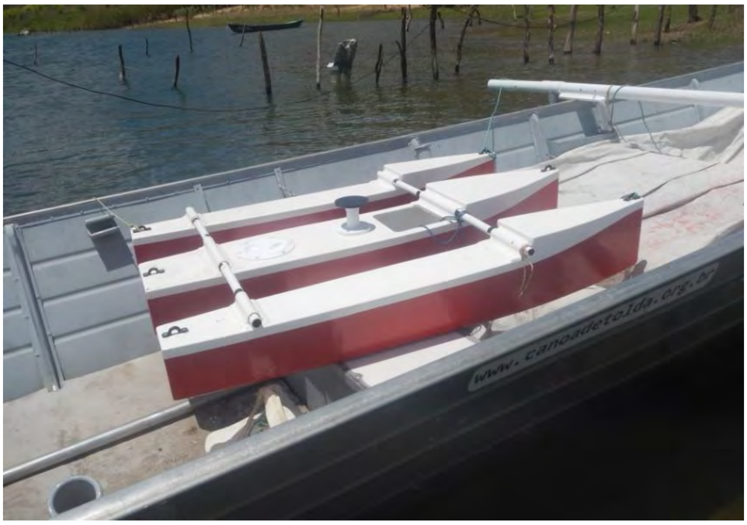


Figure 78 - First stage of testing carried out with total success.

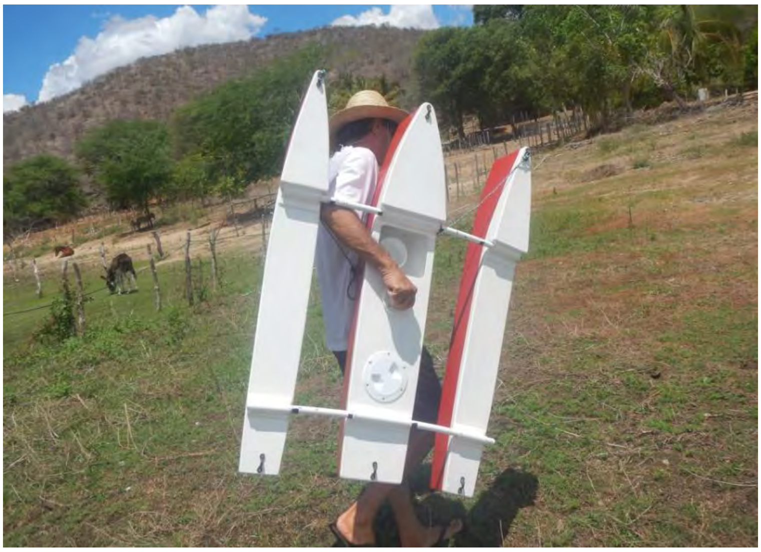


Figure 79 - Back to base, for small adjustments and preparation for new tests.

Preliminary test results, in accordance with pre-established objectives.

	Specific objectives	Evaluation	Comments
1	Heading stability	Approved.	Extremely stable vessel, without the need to install heading control devices (rudders, keels).
2	Behavior when passing waves	Approved	Both in favor of the waves and against them, in seas with small swells, the result confirms the choice of section shapes and volume distribution of the central and floating hulls.
3	Transverse stability	Approved	Same as item 2.

4	Waves generated by hull drag	Approved	Same as item 2.
5	Wake generated by hulls	Approved	Same as item 2.
6	Behavior when maneuvering turns	Approved	Same as item 2.
7	Deeper Pro System/Control Device Communication	Approved	The Deeper Pro compartment was designed so as not to interfere with signal propagation.
8	Deeper Pro signal stability	Approved	The design of the hulls and the location of the sonar prevent it from leaving the water.
9	Anomalies	To be reviewed	1. The flexibility (not extreme) of the PVC connection arms. They will be replaced by aluminum. 2. The system for fixing the arms in the sockets in the hulls must be improved, to avoid mobility of the memos.

7. Next steps

Tests with varying loads are planned in the coming weeks in order to reach a maximum displacement of 13 kg.

After the final tests, a prototype is expected to be sent to Professor Paulo Victor Araújo's team, for the development and integration of motorization/propulsion and remote control systems, as well as other types of water monitoring sensors.

8. A little further

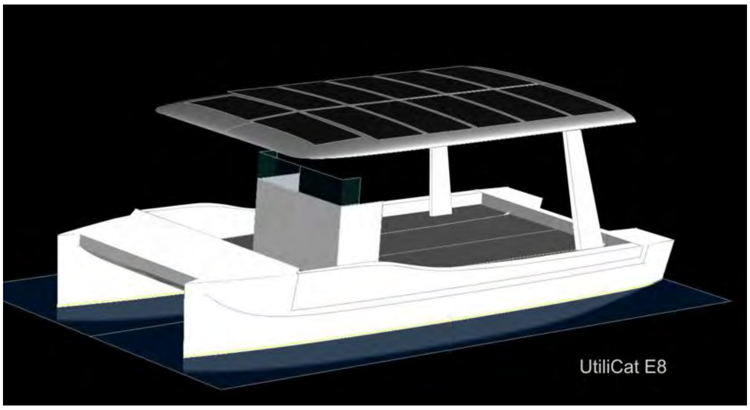
In order to optimize the time invested in developing the monitoring trimaran, its side hulls are (on a reduced scale, naturally) similar to those of the Utilicat E8 catamaran, an 8-meter utility catamaran with conventional stationary electric motors.

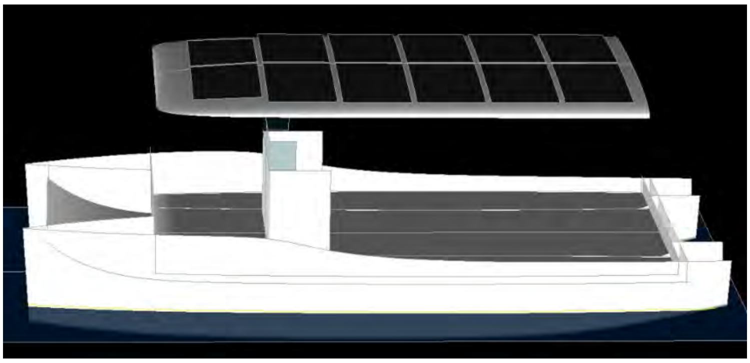
The Utilicat E8 is in the conceptual phase, as one of the models in a line of multihull utility vessels (catamarans and trimarans) with sail and motorized (electric motors) for multiple uses to serve less favored communities and with precarious access to public policies that serve situations of: regional mobility, collective health, school transport, transport of goods from local producers, environmental monitoring, medical evacuation, garbage collection, evacuation/transport of items in case of extreme events (floods, epidemic outbreaks, forest fires), etc. .

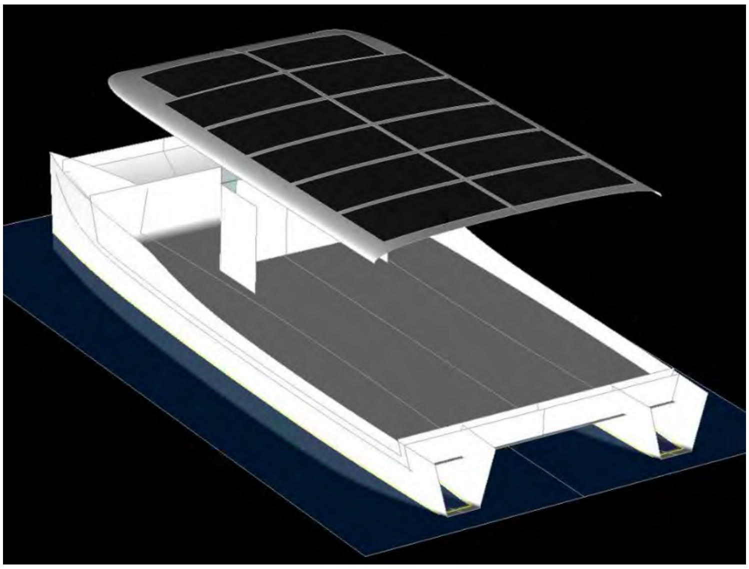
All designed models must be capable of construction in places with few resources, by qualified people (but without very specific technical knowledge) and must also have adequate performance (both sail and motorized models).

Thus, both the Utilicat E8 and other utility models will have extremely efficient, low-drag hulls, which means, particularly in the case of motorized models, lower installed power.

The monitoring trimaran's floats will be used (in sea trials) to simulate the Utilicat E8 catamaran in order to produce data that will be incorporated into project development.







Reserva Mato da Onça, 15th January 2024

Carlos Eduardo Ribeiro Junior

Anexos

Vídeos

GX011869.MP4 – Navigation with the waves. View from the front.
GX011871.MP4 – Navigation with the waves. View from the front, top.
GX011872.MP4 – Navigation with the waves. View from the side, top.
GX011873.MP4 – Navigation with the waves. View from the bow, from the bow of the boat.
GX011884.MP4 – Navigation with the waves. View from the stern.
GX011895.MP4 – Navigation against the waves. View from the bow.
GX011897.MP4 – Navigation against the waves. View from the front, more closed.
GX011898.MP4 – Navigation against the waves. View from the front, bigger waves.
GX011899.MP4 – Navigation with the waves. View from the front, bigger waves.